(Courtesy of Stockton Chamber of Commerce)

Portion of Stockton and Its Deep-water Harbor
Mt. Diablo in Background

STATE OF CALIFORNIA
GOODWIN J. KNIGHT
GOVERNOR

PUBLICATION OF
STATE WATER RESOURCES BOARD

Bulletin No. 11

SAN JOAQUIN COUNTY INVESTIGATION

June, 1955

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GOODWIN J. KNIGHT
GOVERNOR

STATE OF CALIFORNIA
STATE WATER RESOURCES BOARD
PUBLIC WORKS BUILDING
SACRAMENTO 5, CALIFORNIA

June 30, 1955

ADDRESS ALL COMMUNICATIONS TO THE SECRETARY

HONORABLE GOODWIN J. KNIGHT, *Governor, and*
Members of the Legislature of the
State of California

GENTLEMEN: I have the honor to transmit herewith Bulletin No. 11 of the State Water Resources Board, entitled "San Joaquin County Investigation," as authorized by Chapter 1514, Statutes of 1945, as amended.

The San Joaquin County Investigation was conducted and Bulletin No. 11 was prepared by the Division of Water Resources of the Department of Public Works, under the direction of the State Water Resources Board.

Bulletin No. 11 contains an inventory of the underground and surface water resources of the valley floor lands of San Joaquin County lying east of the Delta and north of the South San Joaquin and Oakdale Irrigation Districts, estimates of present and probable ultimate water utilization, estimates of present and probable ultimate supplemental water requirements, and preliminary plans and cost estimates for water development works.

Very truly yours,

Clair A Hill
CLAIR A. HILL, Chairman

ACKNOWLEDGMENT

Valuable assistance and data used in the investigation were contributed by agencies of the Federal Government, cities, counties, public districts, and by private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is also made of the helpful cooperation of the Board of Supervisors of San Joaquin County, the North San Joaquin Water Conservation District, the Stockton and East San Joaquin Water Conservation District, the Farmington Water Conservation Committee, the East Bay Municipal Utility District, the Pacific Gas and Electric Company, the Woodbridge Irrigation District, the Oakdale Irrigation District, the South San Joaquin Irrigation District, the City of Stockton, the City of Lodi, and the California Water Service Company.

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CHAPTER I

INTRODUCTION

In common with many other parts of California, the area in San Joaquin County under this investigation has recently experienced an increase in water utilization, and as a result is confronted with a need for more complete conservation of its water resources. An accelerated increase in ground water use in recent years, combined with progressive lowering of pumping levels, has brought about local concern regarding the adequacy of the ground water resources of San Joaquin County.

AUTHORIZATION FOR INVESTIGATION

In consideration of the adverse ground water situation in San Joaquin County, representatives of local interests in the Calaveras River, Mokelumne River, and Farmington-Collegeville areas appeared before the State Water Resources Board at Sacramento on September 5, 1947, March 5, 1948, and September 2, 1949, respectively, and requested state-county cooperative surveys of ground water supplies of each of these areas. The Board referred the requests to the State Engineer for preliminary examination and report on the need for such investigations, and estimates of their scope, duration, and cost.

The State Water Resources Board, on October 3, 1947, approved a recommendation by the State Engineer, based on findings of a preliminary examination, for a two-year cooperative investigation of the Calaveras River area, and authorized negotiation of an agreement with local agencies. The agreement, between the State Water Resources Board, the County of San Joaquin, and the State Department of Public Works acting through the agency of the State Engineer, was executed on February 19, 1948. It provided that the work under the agreement

> "shall consist of investigation and report on the underground water supply in the Calaveras River Area, bounded approximately by Bellota on the east, the San Joaquin River on the west, Duck Creek on the south, and Bear Creek on the north, in the County of San Joaquin, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved."

This agreement authorized the provision of funds to meet the costs of investigation for one year. A supplemental agreement executed by the same parties on March 23, 1949, authorized funds to complete the investigation and report. Funds to meet the costs of the Calaveras River area investigation and report to the extent of $28,000 were provided as follows: State of California (State Water Resources Board), $14,000; and County of San Joaquin, $14,000.

On July 2, 1948, the State Water Resources Board approved a recommendation by the State Engineer, based on findings of a preliminary examination, for a similar two-year cooperative investigation of the Mokelumne River area, and authorized negotiation of an agreement with local agencies. This agreement, between the State Water Resources Board, the County of San Joaquin, and the State Department of Public Works acting through the agency of the State Engineer, was executed on November 10, 1948. It provided that the work under the agreement

> "shall consist of investigation and report on the underground water supply in the Mokelumne River Area, bounded approximately by Clements on the east, the San Joaquin River on the west, Bear Creek on the south, and Dry Creek on the north, in the County of San Joaquin, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved."

This agreement authorized the provision of funds to meet the costs of investigation for one year. A supplemental agreement executed by the same parties on December 6, 1949, authorized funds to complete the investigation and report. Funds to meet the costs of the Mokelumne River area investigation and report to the extent of $25,000 were provided as follows: State of California (State Water Resources Board), $12,500; and County of San Joaquin, $12,500.

On October 7, 1949, the State Water Resources Board approved a recommendation by the State Engineer, based on findings of a preliminary examination, for a two-year cooperative investigation of the Farmington-Collegeville area, and authorized negotiation of an agreement with local agencies. This agreement, between the State Water Resources Board, the County of San Joaquin, and the State Department of Public Works acting through the agency of the State Engineer, was executed on December 1, 1949. It provided that the work under the agreement

> "shall consist of an investigation and report on the ground water supply in said Farmington-Collegeville area, in the County of San Joaquin, including location, replenishment, quality, and utilization thereof, and, if possible, a method or methods of solving the water problems involved."

This agreement authorized the provision of funds to meet the costs of investigation for one year. A supplemental agreement executed by the same parties on December 1, 1950, authorized funds to complete the investigation and report. Funds to meet the costs of the Farmington-Collegeville investigation and report to the extent of $23,000 were provided as follows: State of California (State Water Resources Board), $11,500; and County of San Joaquin, $11,500.

Inasmuch as the foregoing three investigations were implemented by contracts between the State Water Resources Board, the County of San Joaquin, and the State Department of Public Works, and the investigational areas are contiguous and overlie a common ground water basin, the three areas have been combined for consideration in this bulletin into one area designated the "San Joaquin Area." Furthermore, the three investigations are hereinafter jointly referred to as the "San Joaquin County Investigation." The combined reporting of the investigations was concurred in by the several parties to the agreements.

Continuing investigations for one year beyond the periods covered by the foregoing contracts were made in the three areas under agreements between the State Water Resources Board, the Department of Public Works, and, respectively; the North San Joaquin Water Conservation District, dated November 1, 1951; the Stockton and East San Joaquin Water Conservation District, dated May 1, 1952; and the County of San Joaquin, dated June 1, 1952. Each of these agreements provided for a series of ground water level measurements, stream flow measurements, collection and analysis of samples of surface and ground waters, collection of crop survey records, operation and maintenance of certain stream gaging stations, and compilation of results of measurements. Funds to meet the costs of each investigation were provided in equal amounts and for each were: State of California (State Water Resources Board), $1,000; and local agencies, $1,000. Total funds provided were: State of California (State Water Resources Board), $3,000; and local agencies, $3,000.

A study of the beneficial use of water, under permits issued by the Division of Water Resources to the Woodbridge Irrigation District and the Woodbridge Water Users Association, was conducted by the Division in the western portion of the Mokelumne River area during 1952. Data collected during this study were utilized in connection with the investigation reported herein.

Additional funds have been expended in investigation of the San Joaquin Area by the State Water Resources Board in connection with the current State-Wide Water Resources Investigation, certain results of which have been used in connection with the San Joaquin County Investigation.

Copies of the three agreements, and their supplements, between the State Water Resources Board, the County of San Joaquin, and the Department of Public Works, are included as Appendix A. Also included in Appendix A are copies of the three agreements between the State Water Resources Board, local agencies, and the Department of Public Works, for continuing investigations in the three areas.

The State Water Resources Board, at its regular meeting on May 7, 1954, approved release of the preliminary draft of Bulletin No. 11, "San Joaquin County Investigation," to concerned agencies for their review and comment. Comments were received from 12 agencies. These comments were reviewed and suggested changes in the bulletin were adopted where it was considered that they would improve it, and where the Division of Water Resources was in agreement with the changes suggested. Comments submitted by concerned interests after review of the final edition of Bulletin No. 11 are included as Appendix B.

RELATED INVESTIGATIONS AND REPORTS

The following reports of prior investigations, containing information pertinent to evaluation of ground water problems in San Joaquin County, were reviewed in connection with the current investigations:

Barnes, Harry. "Flood Problems of Calaveras River." California State Department of Engineering. October 31, 1919.

California State Department of Public Works, Division of Water Resources. "San Joaquin River Basin." Bulletin No. 29. 1931.

——— "Quality of Ground Water in the Stockton Area, San Joaquin County." Water Quality Investigation, Report No. 7. March, 1955.

California State Water Resources Board. "Water Resources of California." Bulletin No. 1. 1951.

Conkling, Harold. "Report to District Engineer, Sacramento District, Corps of Engineers, Flood Control and Ground Water Replenishment, Bear Creek Area, San Joaquin County, California." October 4, 1946.

Davis, Frank. "Report on Construction of Diversion Works and Quantity of Water Delivered, 1934-1938." Linden Irrigation District. 1939.

Eaton, Frank M. "Boron in Soils and Irrigation Waters and Its Effects on Plants." United States Department of Agriculture. Technical Bulletin 448. February, 1935.

Hall, L. Standish. "Flood Control and Ground Water Replenishment, Bear Creek, San Joaquin County, California." East Bay Municipal Utility District. April, 1946.

——— "Supplemental Flood Control and Ground Water Replenishment, Bear Creek, San Joaquin County, California." East Bay Municipal Utility District. March, 1947.

Mendenhall, W. C., Dole, R. B., and Stabler, Herman. "Ground Water in San Joaquin Valley, California." United States Department of the Interior, Geological Survey. Water-Supply Paper 398. 1916.

Piper, A. M., Gale, H. S., Thomas, H. E., and Robinson, T. W. "Geology and Ground Water Hydrology of the Mokelumne Area, California." United States Department of the Interior, Geological Survey. Water-Supply Paper 780, 1939.

Stearns, H. T., Robinson, T. W., and Taylor, G. H. "Geology and Water Resources of the Mokelumne Area, California." United States Department of the Interior, Geological Survey. Water-Supply Paper 619. 1930.

Taylor, G. H., and Robinson, T. W. "The Water Table in the Calaveras Area, California." United States Department of the Interior, Geological Survey. March 24, 1931.

Tibbetts, Fred H. "Report to the Linden Irrigation District, San Joaquin County, California, on Underground Water Supply and Plans for Providing Additional Irrigation Supply." February, 1931.

——— "Report to Water Advisory Committee on East Central San Joaquin Water Conservation Project." February, 1937.

United States Department of Agriculture, Bureau of Chemistry and Soils. "Soil Survey of the Stockton Area, California." 1906.

——— "Reconnaissance Soil Survey of the Lower San Joaquin Valley, California." 1918.

——— "Soil Survey of the Lodi Area, California." February, 1937.

United States Department of Agriculture, Bureau of Plant Industry, Soils, and Agricultural Engineering. "Soil Survey of the Stockton Area, California." 1951.

United States War Department, Corps of Engineers, Sacramento District. "Brief Definite Project Report Bear Creek, San Joaquin County, California, Selection of Plan of Improvement." November 14, 1947.

Weir, Walter W. "Soils of San Joaquin County, California." University of California, College of Agriculture, Division of Soils. June, 1952.

The Division of Water Resources is presently conducting surveys and studies for the State-Wide Water Resources Investigation, authorized by Chapter 1541, Statutes of 1947. This investigation, under direction of the State Water Resources Board, has as its objective the formulation of The California Water Plan for full conservation, control, and utilization of the State's water resources to meet present and future water needs for all beneficial purposes and uses in all parts of the State, insofar as practicable. Surveys and studies are also being conducted by the Division of Water Resources for the Survey of Mountainous Areas, authorized by Chapter 30, Statutes of 1947. This investigation, which is coordinated with the state-wide investigation, has as its primary objective the determination of probable ultimate water requirements of certain counties of the Sierra Nevada. Results of both of the foregoing investigations will have direct bearing on solutions to the water problems of the San Joaquin Area, particularly with regard to plans to meet supplemental water requirements of the area under ultimate conditions of development.

SCOPE OF INVESTIGATION AND REPORT

It has been stated that under provisions of the authorizing agreements the general objectives of the San Joaquin County Investigation included investigation and study of the underground water supply of valley floor lands in the area, including quality, replenishment, and utilization thereof, and, if possible, a method or methods of solving the water problems involved. In attaining these objectives it was necessary that the scope of the investigation include full consideration of surface as well as ground water supplies, and that it involve determination of present and ultimate water utilization and supplemental water requirements.

Field work in the investigational area, and office studies, as authorized by the initial and supplemental cooperative agreements, commenced in February, 1948, August, 1948, and June, 1949, on the Calaveras River area, the Mokelumne River area, and the Farmington-Collegeville area, respectively. The field work continued into 1954.

In the course of the investigation, precipitation and stream flow records were collected and compiled in order to evaluate water supplies available to the investigational area. Twelve new stream gaging stations were installed and maintained to supplement the available hydrographic data. These stations were on Dry Creek at Forni Ranch, Dry Creek near Ione, Jackson Creek at State Highway 88, Calaveras River at Bellota, Calaveras River at Solari Road, Mormon Slough at Bellota, Duck Creek at Farmington, Duck Creek at Mariposa Road, Lone Tree Creek at Valley Home, Lone Tree Creek at Austin Road, Tempo Creek at Jack Tone Road, and French Camp Slough at Sharps Lane.

In order to determine ground water storage capacity and yield, geologic features of the ground water basin underlying the investigational area were investigated. This survey included the collection and study of about 500 well logs.

The effects of draft on and replenishment of the ground water basin were determined by measurements of static ground water levels made at about 630 wells during each spring and fall of the period of investigation. These wells were chosen to form a comprehensive measuring grid over the entire area. In addition, measurements to determine monthly fluctuations of water levels were made at approximately 100 control wells.

Present land use in the investigational area was determined by complete surveys of valley floor lands. These surveys were conducted in 1948, 1949, and 1952 in the Calaveras River area, in 1949, 1950 and 1952 in the Mokelumne River area, and in 1949, 1950, 1951, and 1952 in the Farmington-Collegeville area. The total area surveyed was about 345,500 acres. The land use survey data were used in conjunction with available data on unit water use to determine total present water requirements in the investigational area.

In order to determine future water requirements, all valley floor lands, excepting those which it is considered would ultimately be devoted to urban and miscellaneous purposes, were classified with regard to their suitability for irrigated agriculture. This involved collection, field checking, and re-evaluation of land classification data from the United States Bureau of Reclamation, supplemented by data from field surveys conducted by the Division of Water Resources.

Current irrigation practices in the investigational area were surveyed in order to determine unit application of water to important crops on lands of various soil types. Records of application of water were collected at 35 plots during the 1948 irrigation season, at 51 plots during the 1949 season, at 26 plots during the 1950 season, and at 23 plots during the 1951 season. The data collected included records of pump discharge, acreage served, crops irrigated, number and period of irrigations, and amount of water applied.

Studies were made of the mineral quality of surface and ground waters, in order to evaluate their suitability for irrigation use and other beneficial purposes. Data used in these studies included some 624 partial and 135 complete mineral analyses of ground water. In addition, a large number of analyses of surface water supplies were collected and studied.

Field reconnaissance surveys, including geologic examinations, were made to locate and evaluate possible dam and reservoir sites for conservation of surface runoff. Reconnaissance surveys were also made of possible routes for conveyance of water to areas of use.

Results of the San Joaquin County Investigation are presented in this report in the four ensuing chapters. Chapter II, "Water Supply," contains evaluations of precipitation and of surface and subsurface inflow and outflow. It also includes results of investigation and study of the ground water basin and contains data regarding mineral quality of surface and ground waters. Chapter III, "Water Utilization and Supplemental Requirements," includes data and estimates of present and probable ultimate land use and water utilization, and contains estimates of present and probable ultimate supplemental water requirements. It also includes available data on demands for water with respect to rates, times, and places of delivery. Chapter IV, "Plans for Water Development," describes preliminary plans for conservation and utilization of available water supplies to meet supplemental water requirements, including operation and yield studies, design considerations and criteria, and cost estimates. Chapter V, "Summary of Conclusions," summarizes the conclusions resulting from the investigation and studies.

AREA UNDER INVESTIGATION

The area under investigation comprises those valley floor lands of San Joaquin County which lie east of the Sacramento-San Joaquin Delta and north of the South San Joaquin and Oakdale Irrigation Districts. As stated in a preceding section of this chapter, this area has been designated the "San Joaquin Area."

The San Joaquin Area is situated on the east side of the northernmost portion of the San Joaquin Valley, near its juncture with the Sacramento Valley, and its northern boundary is about 25 miles south of the City of Sacramento. The area extends north and south for a distance of about 32 miles and has an average width of 17 miles. Its location is indicated on Plate 1, entitled "Location of San Joaquin Area," and the area is shown in greater detail on Plate 2, entitled "Hydrographic Units and Organized Water Agencies, 1952."

In order to facilitate reference to its several parts, the San Joaquin Area was divided into four principal units. These were designated "Western Mokelumne Unit," "Eastern Mokelumne Unit," "Calaveras Unit," and "Littlejohns Unit," and are shown on Plate 2. The Western Mokelumne Unit consists of lands lying generally west of a line between Lodi and Stockton, and extending from the Mokelumne River on the north to Stockton on the south. The Eastern Mokelumne Unit includes lands lying east of Lodi and Stockton between Dry Creek on the north and Bear Creek on the south. The Calaveras Unit embraces the area south of the Eastern and Western Mokelumne Units, lying generally between Bear Creek and Duck Creek and east of the San Joaquin River. The Littlejohns Unit consists of those lands lying south of the Calaveras Unit, east of French Camp Road, and north of Lone Tree Creek.

Drainage Basins

The eastern portion of the San Joaquin Area consists of a gently rolling plain, which merges into nearly flat land over the entire central and western portions. The general ground surface slopes gently from east to west. Included valley floor lands lie below an elevation of about 130 feet. There are no elevations in the area greater than 250 feet above sea level.

The combined drainage areas tributary to the San Joaquin Area total 1,589 square miles. In order of importance, the principal tributary stream systems are those of the Mokelumne and Calaveras Rivers, and of Dry, Littlejohns, Bear, Duck, and Lone Tree Creeks. The extent of the various drainage basins is shown in the following tabulation:

Drainage basin	*Area, in square miles*
Mokelumne River above Clements gaging station	630
Dry Creek above Forni Ranch gaging station	279
Bear Creek above Lockeford gaging station	48
Calaveras River above Jenny Lind gaging station	395
Duck Creek above Farmington gaging station	26
Littlejohns Creek above Farmington gaging station	193
Lone Tree Creek above Valley Home gaging station	18
Total	1,589

The tributary watersheds are in a zone of moderate to heavy precipitation, and their mean seasonal natural runoff during the 53-year period from 1894-95 through 1946-47 is estimated to have averaged approximately 700 acre-feet per square mile.

The San Joaquin Area is traversed in a general east-west direction by all of its tributary streams which empty either directly or indirectly into the San Joaquin River as it enters the Delta. The Mokelumne River and Dry and Bear Creeks traverse the Eastern Mokelumne Unit. Bear Creek is the only stream traversing the Western Mokelumne Unit, emptying into Disappointment Slough on the edge of the Delta, and thence into the San Joaquin River. The Calaveras River and Mormon Slough drain the Calaveras Unit, discharging into the San Joaquin River just west of Stockton. Duck, Littlejohns, Lone Tree, and Tempo Creeks drain the Littlejohns Unit, discharging into French Camp Slough which, in turn, drains into the San Joaquin River just south of Stockton.

Climate

The climate of the San Joaquin Area is characterized by dry summers with high daytime temperatures and warm nights, and wet winters with moderate temperatures. More than 80 percent of the seasonal precipitation falls during the five-month period from November to March, inclusive. The growing season is long, there being 295 days between killing frosts at Stockton, located in the west central portion of the area. Temperatures at Stockton have ranged from 17° F. to 110° F., and the monthly average for the period from 1872 to 1950 ranges from 44.8° F. in January to 74.0° F. in July.

Geology

The San Joaquin Area is underlain by sediments derived by erosion of the Sierra Nevada range to the east and subsequently deposited in the San Joaquin Valley. The Sierra Nevada has been developed on a tilted fault block having a long gentle westerly slope. Geologic formations in the Sierra Nevada are largely pre-Tertiary granitic and metamorphic rocks and Tertiary volcanics.

The geologic formations of the San Joaquin Area consist principally of gravels, sands, silts, and clays, which in the older formations are often consolidated into conglomerates, sandstones, and siltstones. Volcanic material in the form of rhyolitic ash and tuff and andesitic agglomerate is common in certain of the formations. Sediments as old as Cretaceous underlie the area at depth, but the formations of principal interest in the present study range in age from Miocene to Recent. These younger formations generally dip gently to the west-southwest away from the Sierra Nevada, and are all water-bearing to some extent.

Soils

Soils of the San Joaquin Area vary in their physical characteristics and adaptabilities in accordance with differences in parent material, manner of deposition, drainage, and age or degree of development. The soils may be divided into four broad groups: (1) those residual soils formed in place from the underlying bedrock, (2) those derived from old valley fill or terrace deposits, (3) those derived from more recent alluvial deposits, and (4) those derived from organic materials.

The residual soils occur only to a minor extent along the eastern side of the investigational area. These soils are suited for irrigated agriculture wherever topographic conditions are favorable. Crop adaptabilities vary from orchard crops to irrigated pasture, depending upon the depth of soil.

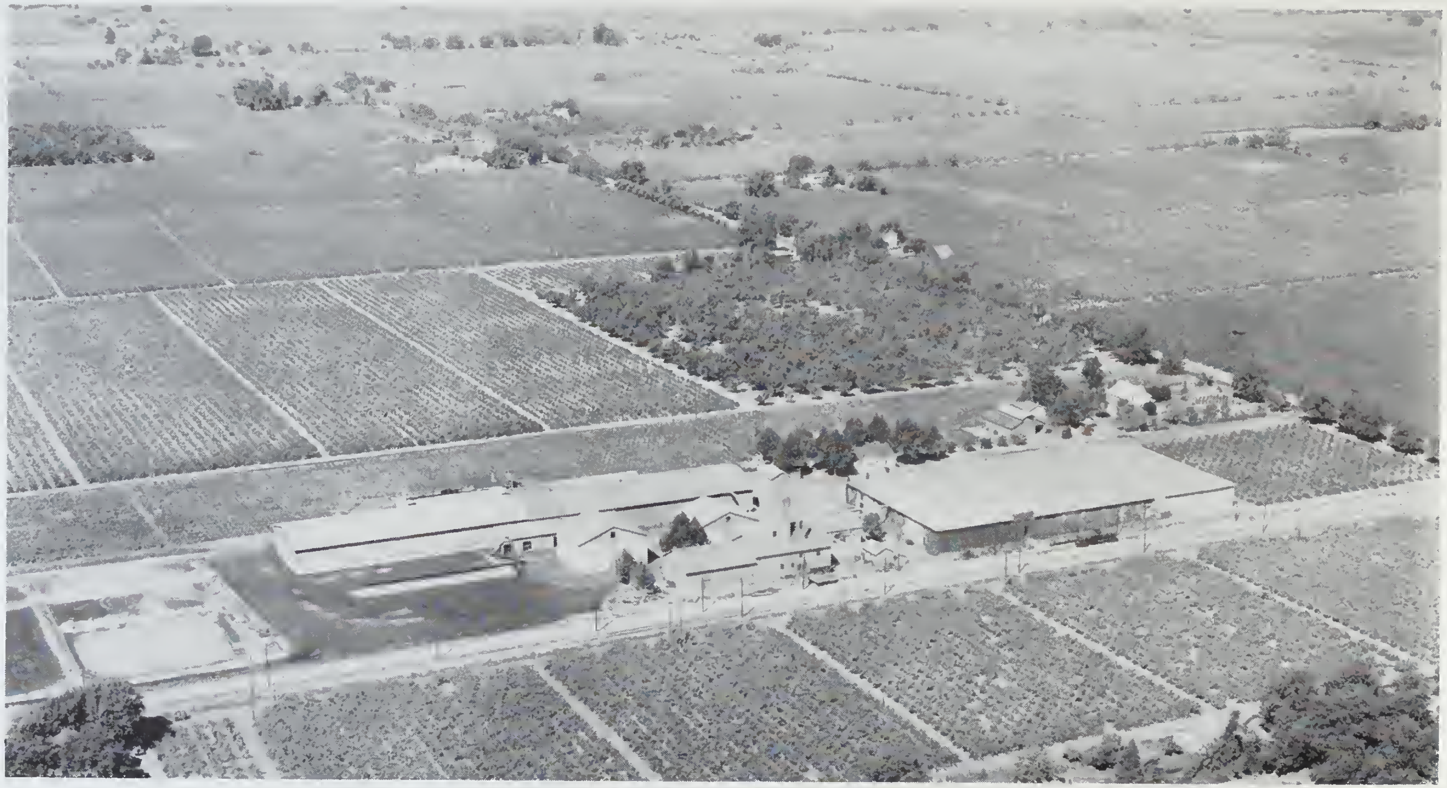
The old valley fill and terrace soils can be further divided into high terrace and low terrace soils. The high terrace soils occur in only small acreages within the area of investigation, and are usually gravelly with moderately compacted to strongly developed hardpan layers. Some of the smoother, less gravelly soils are suitable for irrigated pasture. The lower terrace soils are fairly extensive throughout the San Joaquin Area, occupying a position somewhat lower in elevation than the high terraces and adjacent to the recent alluvial depositions. These soils vary in profile development from moderately compacted to iron-cemented hardpan layers. The hardpan lands are limited to shallow-rooted crops, such as irrigated pasture.

The soils derived from the more recent alluvial deposits can be divided into two broad groups: (1) alluvial fans and flood plain soils, and (2) basin soils. The alluvial fan and flood plain soils occupy rather extensive areas and consist of the more recent depositions of the various stream systems. These soils vary somewhat depending upon the nature of the geological materials within the drainage basin. The soils along the Calaveras River have developed mainly from basic igneous alluvium, whereas the Mokelumne River alluvial fan and flood plain soils are composed largely of granitic rock outwash material. The alluvial fan and flood plain soils are highly valued and have wide crop adaptabilities. The basin soils have developed under very flat, poorly drained conditions. These soils occupy the broad interfan areas between the major streamways, and are quite extensive within the investigational area. Their crop adaptabilities are largely limited to rice and shallow-rooted crops, due to the poor drainage and fine texture of the soils.

The organic or peat soils have developed in place from decomposition of tules, reeds, and other plants. They occur along the western margin of the San Joaquin Area. These soils are highly productive when drained, and are suitable for a wide variety of crops.

Present Development

Development of the northern portion of the San Joaquin Valley has centered in the San Joaquin Area since the first settlements early in the nineteenth



(Courtesy of Lodi Chamber of Commerce)

Winery Near Lodi

century. French Camp is the oldest known settlement in San Joaquin County, having been settled by white trappers in 1828. Stockton became an important transportation center during the gold-rush period due to its accessibility by water from San Francisco. As the county turned to agricultural development, and with the construction of railroads, the surrounding communities of Lodi, Lockeford, Linden, and Farmington were established. The San Joaquin Area embraces a rich agricultural area, and both irrigation and dry farming are of major importance.

The 1950 federal census showed that the population of San Joaquin County was 200,750, an increase of 33 per cent over the 1940 census, which is an indication of the recent rapid growth of the area. The principal urban centers are Stockton and Lodi, which account for some 42 per cent of the total population of the county. The 1950 census enumerated 70,853 persons in Stockton, while 13,798 were counted in Lodi. Thornton, Lockeford, and Linden are the largest of a number of small communities, and the rural population is distributed generally throughout the area.

Agricultural development in the San Joaquin Area began with grain farming shortly after 1850. Early agriculture in the area was stimulated by the influx of settlers during and after the gold rush, but for many years was restricted to the growing of dry-farmed grain crops and stock raising. In 1852 an estimated 4,000 acres of grain were under cultivation in San Joaquin County. During the following three decades agriculture developed tremendously, much of the area being planted in grain, principally wheat. Irrigation developed slowly until the turn of the century when diminishing profits from grain farming, together with the development of more satisfactory irrigation pumps, gave impetus to the increase in irrigated acreage. This transition from dry farming to irrigated cropping has continued to this time.

A survey conducted in 1952 as a part of the current investigation showed that irrigated lands in the San Joaquin Area totaled about 189,900 acres, while approximately 135,900 acres were dry-farmed or fallow. Principal irrigated crops, in order of acreage devoted to each crop, were irrigated pasture, vineyard, deciduous orchard, alfalfa, beans, and tomatoes. Principal dry-farmed crops were barley and wheat.

Industry in the San Joaquin Area is supported largely by agricultural production. Several large canneries are operated during the harvest season to can and dehydrate fruits and vegetables. Packing houses for processing and packing fresh fruits, nuts, and vegetables, and cold storage and refrigeration plants have also been established. Wine making is an important industry in the area, as is the manufacturing of farm machinery. Concrete pipe, generally used in irrigation distribution systems, is manufactured locally. Other industries in the San Joaquin Area include the processing of dairy products, tire molding, die casting, and the manufacturing of wood and canvas products. The completion of the Stockton Deep Water Channel in 1933 has greatly stimulated growth of industry in the area. Electrical energy is available from nearby hydroelectric and steam-electric installations.

Water service agencies in the San Joaquin Area are described in Chapter III. However, several public agencies have been organized in the area to deal with the problems of land reclamation and drainage. The provisions of California reclamation district laws have been used extensively to effect the unwatering of lowlands and their protection from overflow. Active reclamation districts in the area are listed in the following tabulation:

Reclamation district	*Year organized*	*Gross area of district, in acres*
No. 348	1879	10,000
No. 404	1881	2,050
No. 828	1912	700
No. 1608	1914	990
No. 1614	1914	1,770
No. 2020	1917	1,730
No. 2033	1919	4,730*
No. 2074	1927	1,800

* Only about 400 acres of Reclamation District 2033 lie in the San Joaquin Area, along its western edge.

Portions of the San Joaquin Area along its western edge are within the boundaries of the Sacramento and San Joaquin Drainage District, which comprises practically all swamp and overflow lands of both the Sacramento and San Joaquin Valleys. This district was formed in 1911. Areas included within the boundaries of the foregoing agencies, together with water service agencies in the San Joaquin Area, are shown in Plate 2.

Woodward Dam on Simmons Creek

CHAPTER II
WATER SUPPLY

The sources of water supply of the San Joaquin Area are direct precipitation on overlying lands, tributary surface and subsurface inflow, and drainage from bordering irrigation districts. So far as was determined during the investigation, the few imports of water to or exports of water from the San Joaquin Area have been of negligible significance as related to the total water supply. The water supply of the area is considered and evaluated in this chapter under the general headings "Precipitation," "Runoff," "Underground Hydrology," and "Quality of Water."

The following terms are used as defined in connection with the discussion of water supply in this bulletin:

Annual—This refers to the 12-month period from January 1st of a given year through December 31st of the same year, sometimes termed the "calendar year."

Seasonal—This refers to any 12-month period other than the calendar year.

Precipitation Season—The 12-month period from July 1st of a given year through June 30th of the following year.

Runoff Season—The 12-month period from October 1st of a given year through September 30th of the following year.

Investigational Seasons—The four runoff seasons of 1948-49, 1949-50, 1950-51, and 1951-52, during which most of the field work on the San Joaquin County Investigation was performed.

Mean Period—A period chosen to represent conditions of water supply and climate over a long series of years.

Base Period—A period chosen for detailed hydrologic analysis because prevailing conditions of water supply and climate were approximately equivalent to mean conditions, and because adequate data for such hydrologic analysis were available.

Mean—This is used in reference to arithmetical averages relating to mean periods.

Average—This is used in reference to arithmetical averages relating to periods other than mean periods.

In studies for the current State-Wide Water Resources Investigation, it was determined that the 50 years from 1897-98 to 1946-47, inclusive, constituted the most satisfactory period for estimating mean seasonal precipitation generally throughout California. Similarly, the 53-year period from 1894-95 to 1946-47, inclusive, was selected for determining mean seasonal runoff. In studies for the San Joaquin Area, conditions during these periods were considered representative of mean conditions of water supply and climate.

Studies were made to select a base period for hydrologic analysis of the San Joaquin Area during which conditions of water supply and climate would approximate mean conditions, and for which adequate data on inflow, outflow, and ground water levels would be available. It was determined that the 12-year period from 1939-40 to 1950-51, inclusive, was the most satisfactory in this respect. Conditions during this chosen base period so closely approached conditions prevailing during the mean period that they were considered to be equivalent. For this reason, determined relationships between base period water supply and present and probable ultimate water utilization were assumed to be equivalent to corresponding relationships which might be expected under mean conditions of water supply and climate. The water supply presently available to the San Joaquin Area is affected by upstream water utilization, operation of upstream reservoirs, and upstream diversions for export from the tributary watersheds. The largest and most important exportation of water from the watershed above the San Joaquin Area is the diversion from the Mokelumne River at Pardee Reservoir by the East Bay Municipal Utility District, which commenced in 1929 with a water right permit to divert up to a maximum of 200 million gallons per day. The diversion has progressively increased from 16,590 acre-feet in 1929 to 102,830 acre-feet in 1952. To the extent that consumptive use in and exports from watersheds tributary to the San Joaquin Area are increased, the water supply available to the area is correspondingly reduced.

PRECIPITATION

The San Joaquin Area lies within the southern fringe of storms which periodically sweep inland from the North Pacific during winter months. Although the rainfall resulting from these storms is moderate on the average, direct precipitation provides a substantial portion of the water supply of the area.

TABLE 1

MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION AT SELECTED STATIONS IN OR NEAR SAN JOAQUIN AREA

Map reference number	Station	County	Elevation, in feet	Period of record	Source of record	Mean seasonal precipitation, in inches	Maximum and minimum seasonal precipitation	
							Season	Inches
5-1501	Clay	Sacramento	100	1933-1952	EBMUD	*17.18	1940-41 1938-39	26.00 11.90
5-150	Galt	Sacramento	49	1878-1933	USWB	*17.65	1889-90 1923-24	33.60 8.75
5-142	Drytown	Amador	790	1891-1906	USWB	*22.80	1894-95 1897-98	39.94 16.35
5-141	Ione	Amador	287	1878-1915 1915-1952	USWB SPRR	21.22	1936-37 1923-24	34.99 10.50
5-143	Kennedy Mine	Amador	1,500	1892-1947	USWB	28.45	1894-95 1923-24	54.07 13.26
5-154	Camp Pardee	Calaveras	658	1929-1952	EBMUD	*20.24	1935-36 1932-33	29.97 12.67
5-155	Lancha Plana	Calaveras	670	1926-1940	USWB	*20.87	1935-36 1932-33	29.92 12.72
5-157	Mokelumne Hill	Calaveras	1,550	1882-1947	USWB	29.75	1889-90 1923-24	54.59 13.33
5-158	San Andreas	Calaveras	996	1924-1951	USWB	*26.76	1935-36 1923-24	38.76 15.68
5-153	Wallace	Calaveras	200	1926-1952	USWB	*18.93	1949-50 1930-31	27.44 10.32
5-156	Valley Springs	Calaveras	673	1888-1915 1921-1942 1944-1952	USWB Private Private	*21.55	1889-90 1923-24	38.15 10.08
5-172	Jenny Lind	Calaveras	300	1907-1947	USWB	*19.31	1935-36 1923-24	28.87 8.81
5-173	Milton	Calaveras	660	1888-1952	USWB	20.02	1894-95 1923-24	32.31 10.47
5-0159	Clements	San Joaquin	120	1933-1952	EBMUD	*17.60	1936-37 1938-39	24.79 11.09
5-0161	Lind's Airport	San Joaquin	60	**1936-1939	EBMUD	----	----	----
5-0168	Victor	San Joaquin	80	1925-1931 1937-1940	USGS EBMUD	*16.75	1939-40 1938-39	21.03 10.43
5-149	Benson's Ferry	San Joaquin	17	1913-1952	USWB	*15.20	1913-14 1923-24	24.71 8.36
5-151	Elliott	San Joaquin	85	1926-1952	USWB	*16.65	1940-41 1930-31	23.76 10.06
5-169	Lodi	San Joaquin	50	1889-1952	USWB	16.51	1889-90 1897-98	33.45 9.30
5-152	Lockeford	San Joaquin	106	1926-1952	Private	*16.24	1936-37 1930-31	23.04 9.96
5-171	Bellota	San Joaquin	130	1911-1929	USWB	*18.59	1913-14 1923-24	25.02 9.57
5-176	Stockton	San Joaquin	15	1867-1952	USWB	14.10	1906-07 1870-71	22.49 6.73
5-187	Tracy	San Joaquin	54	1879-1945	USWB	*9.55	1889-90 1916-17	24.92 4.59
5-188	Lathrop	San Joaquin	27	1897-1947	USWB	11.43	1940-41 1897-98	16.49 3.96
5-177	Farmington	San Joaquin	111	1877-1915 1919-1952	USWB Private	15.21	1889-90 1911-12	24.82 7.93
5-194	Westley	Stanislaus	90	1889-1918	USWB	*10.53	1913-14 1912-13	17.23 3.96

TABLE 1—Continued

MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION AT SELECTED STATIONS IN OR NEAR SAN JOAQUIN AREA

Map reference number	Station	County	Elevation, in feet	Period of record	Source of record	Mean seasonal precipitation, in inches	Maximum and minimum seasonal precipitation	
							Season	Inches
5-195	Modesto	Stanislaus	90	1871-1952	USWB	11.37	1906-07 1912-13	19.04 3.58
5-178	Oakdale, Woodward Dam	Stanislaus	215	1880-1943	USWB	*13.86	1906-07 1912-13	22.62 6.42
SJ-1	Child's Ranch	San Joaquin	150	1937-1941	EBMUD	*17.61	1939-40 1938-39	22.89 11.99
SJ-2	Marshall Ranch	San Joaquin	60	1925-1929 1937-1952	USGS EBMUD	*15.28	1951-52 1938-39	21.91 9.79
SJ-3	Moffatt Ranch	San Joaquin	75	**1937-1940	EBMUD	----	----	----
SJ-4	Woodbridge	San Joaquin	45	1937-1944	EBMUD	*15.86	1940-41 1938-39	23.03 10.15
SJ-5	Youngstown	San Joaquin	65	1938-1952	EBMUD	*15.08	1951-52 1946-47	22.41 10.10

* Estimate.
** Incomplete records.
USWB—United States Weather Bureau.
EBMUD—East Bay Municipal Utility District.
SPRR—Southern Pacific Railroad Company.

Precipitation Stations and Records

Twenty-eight precipitation stations in or adjacent to the San Joaquin Area have unbroken records of ten years' duration or longer. These stations are fairly well distributed areally and their records were sufficient to provide an adequate pattern of precipitation. Most of the records of precipitation have been published in bulletins of the United States Weather Bureau. Unpublished records at several additional stations were obtained from local agencies and individuals, and are included as Appendix C. Locations of the precipitation stations are shown on Plate 3, entitled "Lines of Equal Mean Seasonal Precipitation," with map reference numbers corresponding to those utilized in State Water Resources Board Bulletin No. 1, "Water Resources of California." The stations and map reference numbers are listed in Table 1, together with elevations of the stations, periods and sources of record, and mean, maximum, and minimum seasonal precipitation. In those instances where it was necessary, precipitation records were extended to cover the 50-year mean period by comparison with records of nearby stations having records covering this period.

Precipitation Characteristics

Because of the uniformity of the general precipitation pattern in the San Joaquin Area, as indicated on Plate 3, precipitation at Stockton was considered to be fairly representative of rainfall over the area. A record of precipitation at Stockton was available from a United States Weather Bureau station maintained since 1867-68. Recorded seasonal precipitation at this station is presented in Table 2 and shown on Plate 4, entitled "Recorded Seasonal Precipitation at Stockton."

Precipitation in the San Joaquin Area consists almost entirely of rainfall, and snowfall is rare. It increases generally from southwest to northeast, as shown on Plate 3. Mean seasonal depth of precipitation ranges from about 13 inches along the southwestern boundary of the area to about 18 inches at its extreme easterly limit. At Farmington, in the southern portion of the area, mean seasonal precipitation is about 15 inches, whereas at Galt, about one mile north of the area, it is approximately 18 inches.

Precipitation varies over wide limits from season to season, ranging from less than 50 per cent of the seasonal mean to over 200 per cent. Maximum seasonal precipitation at Stockton occurred in 1906-07 when 22.49 inches of rain were recorded. In 1870-71, the minimum season at this station, precipitation was only 6.73 inches. Long-term trends in precipitation in the San Joaquin Area are indicated on Plate 5, entitled "Accumulated Departure From Mean Seasonal Precipitation at Stockton."

More than 80 per cent of the seasonal precipitation in the San Joaquin Area occurs during the five months from November through March, on the average, and the summers are dry. Mean monthly distribution of precipitation as recorded at Stockton is presented in Table 3.

TABLE 2

RECORDED SEASONAL PRECIPITATION AT STOCKTON, 1867-68 THROUGH 1951-52

(In inches)

Season	Precipitation	Season	Precipitation
1867-68	20.71	1909-10	13.81
68-69	16.45	10-11	19.93
		11-12	9.06
1869-70	7.64	12-13	7.30
70-71	6.73	13-14	17.89
71-72	20.80		
72-73	13.28	1914-15	17.46
73-74	15.17	15-16	18.04
		16-17	10.87
1874-75	11.14	17-18	8.79
75-76	18.26	18-19	15.89
76-77	7.10		
77-78	18.76	1919-20	7.79
78-79	11.46	20-21	15.06
		21-22	14.66
1879-80	15.34	22-23	16.71
80-81	14.68	23-24	6.81
81-82	9.69		
82-83	15.26	1924-25	18.04
83-84	20.36	25-26	12.81
		26-27	15.35
1884-85	9.59	27-28	11.47
85-86	17.39	28-29	9.72
86-87	7.83		
87-88	10.83	1929-30	10.52
88-89	12.99	30-31	9.60
		31-32	13.06
1889-90	22.37	32-33	9.55
90-91	10.09	33-34	9.59
91-92	12.21		
92-93	15.89	1934-35	14.18
93-94	15.83	35-36	17.38
		36-37	17.89
1894-95	19.78	37-38	17.78
95-96	14.70	38-39	10.21
96-97	12.62		
97-98	6.94	1939-40	17.35
98-99	14.40	40-41	18.40
		41-42	19.98
1899-1900	16.29	42-43	18.00
00-01	16.74	43-44	13.42
01-02	14.03		
02-03	14.54	1944-45	14.81
03-04	14.23	45-46	13.14
		46-47	9.13
1904-05	18.19	47-48	11.75
05-06	18.68	48-49	11.15
06-07	22.49		
07-08	11.09	1949-50	10.57
08-09	15.89	50-51	17.13
		51-52	19.56

Average for 12-year base period, 1939-40 through 1950-51: 14.57 inches

Mean for 50-year period, 1897-98 through 1946-47: 14.10 inches

Average for 85-year period of record, 1867-68 through 1951-52: 14.12 inches

Quantity of Precipitation

The mean seasonal quantity of precipitation in the San Joaquin Area was estimated by plotting recorded or estimated mean seasonal depth of precipitation at stations in or near the area on a map. Lines of equal mean seasonal precipitation, or isohyets, were then drawn, as are shown on Plate 3. By planimetering the areas between these isohyets, the weighted mean seasonal depth and total quantity of precipitation were estimated.

In order to determine seasonal depth and quantity of precipitation during the base period and investi-

TABLE 3

MEAN MONTHLY DISTRIBUTION OF PRECIPITATION AT STOCKTON

Month	Precipitation, in inches	Precipitation, in per cent of seasonal total	Month	Precipitation, in inches	Precipitation, in per cent of seasonal total
July	0.00	0.0	January	2.93	20.8
August	0.01	0.0	February	2.43	17.3
September	0.23	1.6	March	2.06	14.6
October	0.68	4.8	April	1.03	7.3
November	1.41	10.0	May	0.56	4.0
December	2.65	18.8	June	0.11	0.8
			TOTALS	14.10	100.0

gational seasons, the foregoing estimates for the mean period were adjusted on the basis of the average of recorded precipitation at Stockton, Farmington, and Lockeford. The results of the estimates are presented in Table 4, which also shows the precipitation index for the base period and each of the investigational seasons. The term "precipitation index" refers to the ratio of the amount of precipitation during a given season to the mean seasonal amount, and is expressed as a percentage.

TABLE 4

ESTIMATED WEIGHTED SEASONAL DEPTH AND TOTAL QUANTITY OF PRECIPITATION ON SAN JOAQUIN AREA

Season	Precipitation index	Precipitation: Depth, in inches	Precipitation: Quantity, in acre-feet
1948-49	80	12.3	374,000
49-50	82	12.7	385,000
50-51	118	18.2	552,000
51-52	134	20.6	625,000
Average for 12-year base period, 1939-40 through 1950-51	100	15.4	468,000
Mean for 50-year period, 1897-98 through 1946-47	100	15.4	468,000

RUNOFF

Runoff from the highly productive watersheds of the Sierra Nevada constitutes the most important source of water supply available to the San Joaquin Area, which embraces the valley floor lands between the Sierra Nevada and the Sacramento-San Joaquin Delta. The Mokelumne River, which traverses the area from east to west, is the principal tributary stream. There is considerable development and use of the waters of the Mokelumne at the present time, and further development is planned in the near future. Conservation works exist also on the Calaveras River and Littlejohns Creek. Streams tributary to the San

Joaquin Area, with further regulation and development, are a potential source of water to meet present and future requirements in the area.

Stream Gaging Stations and Records

Available records of runoff of the principal streams of the San Joaquin Area were sufficient in number, length, and reliability for purposes of required hydrographic studies. With respect to certain of the smaller streams, however, records of runoff were nonexistent or confined principally to measurements made during the investigational seasons. By comparison with records of nearby stations on major streams, adequate estimates were made of runoff of these smaller streams.

Table 5 lists those stream gaging stations pertinent to the hydrography of the San Joaquin Area, together with their map reference numbers, drainage areas above stations where significant, and periods and sources of records. These stations are also shown on Plate 3. The map reference numbers for the first nine stations listed correspond to those used in State Water Resources Board Bulletin No. 1, "Water Resources of California." New map reference numbers were assigned to the remaining stations listed. The last 11 stations were installed, operated, and maintained as a part of the San Joaquin County Investigation. Most of the runoff records listed in Table 5 have been published by the United States Geological Survey in its Water-Supply Papers, or by the Division of Water

TABLE 5

STREAM GAGING STATIONS IN OR NEAR SAN JOAQUIN AREA

Map reference number	Stream	Station	Drainage area, in square miles	Period of record	Source of record
5-818	Mokelumne River	at Clements	630	1904-1952	USGS
5-822	Mokelumne River	at Woodbridge	644	1924-1952	USGS
5-821	Woodbridge Canal	at diversion	---	1926-1952	USGS
5-791	Bear Creek	near Lockeford	48.4	1930-1933 1933-1943 1944-1952	USGS EBMUD USGS
5-827	Dry Creek	at Forni Ranch	279	1911-1912 1925-1932 1948-1949	USGS USGS DWR
5-829	Dry Creek	near Galt	346	1926-1933 1933-1939	USGS EBMUD
5-829a	Dry Creek	near Galt	325	1941-1944 1944-1951	USBR USGS and DWR
5-786	Calaveras River	at Jenny Lind	395	1907-1952	USGS
5-785	Cosgrove Creek	near Valley Springs	20.6	1929-1952	USGS
5-789	Stockton Diverting Canal	at Stockton	---	1944-1952	USGS
5-784	Littlejohns Creek	at Farmington	193	1925-1926 1942-1944 1946-1952	USGS USBR USCE
SJ-1	Calaveras River	at Bellota	---	1948-1952	DWR
SJ-2	Calaveras River	near Stockton	---	1948-1952	DWR
SJ-3	Mormon Slough	at Bellota	---	1948-1952	DWR
SJ-4	Dry Creek	near Ione	183	1949-1950	DWR
SJ-5	Jackson Creek	at State Highway 88	76	1949-1950	DWR
SJ-6	Duck Creek	at Farmington	25.9	1949-1952	DWR
SJ-7	Duck Creek	near Stockton	---	1949-1952	DWR
SJ-8	Lone Tree Creek	at Valley Home	17.7	1949-1952	DWR
SJ-9	Lone Tree Creek	at Austin Road	---	1949-1952	DWR
SJ-10	Tempo Creek	at Jack Tone Road	12.0	1950-1952	DWR
SJ-11	French Camp Slough	at Sharps Lane	---	1949-1952	DWR

USGS—United States Geological Survey.
EBMUD—East Bay Municipal Utility District.
DWR—Division of Water Resources.
USBR—United States Bureau of Reclamation.
USCE—United States Corps of Engineers.

Resources in its Reports of Sacramento-San Joaquin Water Supervision. The following records have not been published elsewhere, and are included in Appendix D:

Station	*Period of record*
Dry Creek near Galt	1933-1939; 1942-1944
Dry Creek near Ione	January, 1950-May, 1950
Jackson Creek at State Highway 88	January, 1950-April, 1950
Bear Creek at Lockeford	1933-1943
Littlejohns Creek at Farmington	1942-1944 February, 1946-September, 1952

Runoff Characteristics

An excellent continuous record of flow of the Mokelumne River at Clements is available for the period since October, 1904, when a stream gaging station was established by the United States Geological Survey. This record provides a measure of flow of the Mokelumne River into the San Joaquin Area. A similar continuous record of flow of the Calaveras River at Jenny Lind is available for the period since January, 1907, when a stream gaging station was established by the United States Geological Survey. This record likewise provides a measure of flow of the Calaveras River into the San Joaquin Area. Since the Mokelumne River is by far the largest tributary stream, and has the longest period of record, it is considered that its record of flow more nearly reflects characteristics of tributary runoff to the San Joaquin Area than do records of flow on other tributary streams.

Flow of the Mokelumne River to the valley floor is impaired by operation of Pardee Dam and Reservoir and several smaller upstream reservoirs and hydroelectric plants. An estimate of the natural runoff of the Mokelumne River at Clements, as it would be if unimpaired by upstream diversion, storage, import, export, or change in upstream consumptive use of water caused by development, is included in State Water Resources Board Bulletin No. 1, "Water Resources of California." This estimate, together with recorded seasonal runoff of the Mokelumne at Clements, is presented in Table 6. The estimate of natural flow is also shown graphically on Plate 6, entitled "Estimated Seasonal Natural Runoff of Mokelumne River at Clements."

Estimates of natural flow of streams of the San Joaquin Area indicate that average seasonal runoff during the 12-year base period approximated the seasonal mean during the 53-year period. For the Mokelumne and Calaveras Rivers, these estimates were obtained from State Water Resources Board Bulletin No. 1. Natural flow of Dry Creek, Littlejohns Creek, and minor streams tributary to the area was estimated during the current investigation. The estimates of natural flow are presented in Table 7, together with runoff indices for the combined natural flow of streams tributary to the San Joaquin Area. The term

TABLE 6

RECORDED AND ESTIMATED SEASONAL NATURAL RUNOFF OF MOKELUMNE RIVER AT CLEMENTS

(In acre-feet)

Season	Recorded runoff at Clements	Estimated natural runoff at Clements	Season	Recorded runoff at Clements	Estimated natural runoff at Clements
1894-95		1,449,000	1924-25	824,000	835,000
95-96		790,000	25-26	374,000	375,000
96-97		1,025,000	26-27	877,000	896,000
97-98		360,000	27-28	639,000	640,000
98-99		582,000	28-29	288,000	342,000
1899-1900		733,000	1929-30	300,000	467,000
00-01		1,209,000	30-31	187,000	212,000
01-02		646,000	31-32	492,000	764,000
02-03		794,000	32-33	382,000	412,000
03-04		1,338,000	33-34	360,000	302,000
1904-05	629,000	665,000	1934-35	539,800	736,000
05-06	1,360,000	1,374,000	35-36	860,200	935,000
06-07	1,720,000	1,737,000	36-37	673,700	742,000
07-08	475,000	480,000	37-38	1,208,000	1,308,000
08-09	1,160,000	1,177,000	38-39	413,000	347,000
1909-10	906,000	919,000	1939-40	734,200	903,000
10-11	1,530,000	1,533,000	40-41	778,000	873,000
11-12	393,000	401,000	41-42	934,100	1,012,000
12-13	423,000	438,000	42-43	998,800	1,054,000
13-14	1,080,000	1,087,000	43-44	386,200	460,000
1914-15	823,000	837,000	1944-45	666,300	799,000
15-16	1,030,000	1,042,000	45-46	645,700	761,000
16-17	868,000	877,000	46-47	305,100	404,000
17-18	521,000	527,000	47-48	460,500	649,000
18-19	590,000	596,000	48-49	408,400	529,000
1919-20	464,000	469,000	1949-50	607,300	766,000
20-21	865,000	875,000	50-51	1,107,000	1,234,000
21-22	919,000	925,000	51-52	1,190,200	1,352,000
22-23	703,000	710,000			
23-24	182,000	187,000			

Mean seasonal natural runoff for 53-year period, 1894-95 through 1946-47: 780,000 acre-feet

"runoff index" refers to the ratio of the amount of runoff during a given season to the mean seasonal amount, and is expressed as a percentage.

Discharge of streams tributary to the San Joaquin Area varies between wide limits from season to season, and within the season. This is indicated by flow of the Mokelumne River at Clements, where the maximum recorded seasonal runoff occurred in 1906-07 and amounted to 1,720,000 acre-feet. The minimum seasonal runoff recorded at this station occurred in 1923-24 and was less than 182,000 acre-feet. Maximum recorded instantaneous discharge was 28,800 second-feet on November 21, 1950, and flow recorded on July 9 and August 15, 20, 21, 22, and 23, 1934, was zero. Estimated mean monthly distribution of natural flow of the Mokelumne River at Clements is presented in Table 8.

Quantity of Runoff

Available records of stream flow, including those obtained from measurements made in connection with the investigation, were sufficient to permit fairly re-

TABLE 7

ESTIMATED SEASONAL NATURAL FLOW OF STREAMS TRIBUTARY TO SAN JOAQUIN AREA, 1939-40 THROUGH 1951-52

(In acre-feet)

Season	Runoff index	Mokelumne River at Clements	Calaveras River at Jenny Lind	Dry Creek near Ione	Littlejohns Creek at Farmington	Minor streams	Combined flow
1939-40	115	903,000	208,000	99,500	63,300	60,000	1,333,800
40-41	111	873,000	202,000	86,300	63,900	60,000	1,285,200
41-42	126	1,012,000	200,000	148,900	50,500	50,000	1,461,400
42-43	144	1,054,000	276,000	208,100	66,800	63,000	1,667,900
43-44	56	460,000	77,400	52,500	39,700	21,500	651,100
1944-45	99	799,000	154,000	125,600	34,100	37,400	1,150,100
45-46	86	761,000	117,000	98,100	14,200	12,000	1,002,300
46-47	42	404,000	49,100	24,800	12,300	1,800	492,000
47-48	69	649,000	82,000	49,100	13,100	11,400	804,600
48-49	60	529,000	79,600	48,600	16,500	16,800	690,500
1949-50	87	766,000	120,500	65,900	35,800	23,900	1,012,100
50-51	165	1,234,000	306,500	219,400	88,400	65,400	1,913,700
51-52	182	1,352,000	333,600	234,800	101,000	85,000	2,106,400
Average for 12-year base period, 1939-40 through 1950-51	97	787,000	156,000	102,200	41,500	35,300	1,122,000
53-year mean	100	780,000	199,000	97,000	43,100	40,000	1,159,100

TABLE 8

ESTIMATED MEAN MONTHLY DISTRIBUTION OF NATURAL FLOW OF MOKELUMNE RIVER AT CLEMENTS

Month	Runoff, in acre-feet	Per cent of seasonal total
October	5,500	0.7
November	15,600	2.0
December	28,100	3.6
January	46,000	5.9
February	64,700	8.3
March	94,400	12.1
April	138,800	17.8
May	203,600	26.1
June	144,300	18.5
July	32,800	4.2
August	3,900	0.5
September	2,300	0.3
TOTALS	780,000	100.0

liable determination of surface inflow to and surface outflow from the San Joaquin Area during the 12-year base period, and during the seasons of the investigation. However, surface inflow available to the area is affected by upstream water utilization, operation of upstream reservoirs, and upstream diversions for export from the tributary watersheds. It is emphasized that, to the extent that consumptive use in and exports from these watersheds are increased, surface inflow to the area would be correspondingly reduced.

Surface inflow to the San Joaquin Area from the Mokelumne River was directly measured at the Clements station. Inflow from the Calaveras River was determined from recorded flow at Jenny Lind, plus unmeasured inflow between Jenny Lind and Bellota, which in turn was determined by correlation with recorded flow of Bear Creek at Lockeford. Inflow from Dry Creek was estimated from records of flow of Sutter Creek from October, 1939, to December, 1941, of the Cosumnes River from January, 1941, to September, 1942, and of Dry Creek at Galt from October, 1942, to September, 1948. The flow of Dry Creek was measured at Forni Ranch during the 1948-49 season, and by the combined flow of Dry Creek near Ione and Jackson Creek at State Highway 88 for the 1949-50 season. Inflow from Littlejohns Creek was measured at the Farmington station for all but the first three seasons of the 12-year base period. For those seasons when records were not available, inflow from Littlejohns Creek was estimated by correlation with recorded flow of Bear Creek at Lockeford. Inflow to the area from Duck Creek at Farmington, Lone Tree Creek at Valley Home, and Tempo Creek at Jack Tone Road, was estimated for seasons when records were not available by correlation with recorded flow of Bear Creek at Lockeford.

Surface outflow from the San Joaquin Area in the Mokelumne River was directly measured at the Woodbridge station. Although this station is several miles east of the western boundary of the area, net accretion to the river west of this station is considered negligible, with the exception of water from Dry Creek which discharges into the Mokelumne near Thornton. Outflow from Dry Creek was directly measured near Galt from 1942-43 to 1950-51, inclusive. The flow of Dry Creek near Galt for the three seasons 1939-40 to 1941-42, inclusive, was estimated by correlation with the flow of Sutter Creek and the Cosumnes River. Surface outflow in the Calaveras River was directly measured at the Stockton Diverting Canal immediately north of Stockton from 1944 to the pres-

Looking Westerly From Outlet of Woodward Dam on Simmons Creek ent time, and at the mouth of the old Calaveras River channel from 1948-49 through 1951-52. Surface outflow from the Western Mokelumne Unit during the 12-year base period from 1939-40 through 1950-51 was estimated. The outflow from this unit is made up of waste water from the laterals of the Woodbridge Irrigation District and from reclamation pumps in the sloughs of the western edge of the unit. The waste of the Woodbridge Irrigation District was directly measured during 1952, and was estimated for the other years from this study and studies made by the East Bay Municipal Utility District from 1926 through 1936. Outflow pumped by reclamation pumps was estimated from studies made in similar areas where a percentage factor of water pumped was related to water applied, and from rainfall. Outflow in French Camp Slough and Duck Creek was directly measured during the seasons of investigation, and was estimated during those seasons when no records were available.

Measured and estimated seasonal surface inflow to and outflow from the San Joaquin Area during the base period and during 1951-52 are presented in Table 9.

UNDERGROUND HYDROLOGY

The San Joaquin Area overlies a portion of the ground water basin of the San Joaquin Valley, and water pumped from storage in the basin presently serves nearly 80 per cent of the land irrigated in the area. Percolation of rainfall, stream flow, drainage from adjacent hills, and of the unconsumed portion of applied irrigation water, is the most important source of ground water replenishment.

The term "free ground water," as used in this bulletin, generally refers to a body of ground water not overlain by impervious materials, and moving under control of the water table slope. "Confined ground water" refers to a body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying water, and moving under pressure caused by the difference in head between intake and discharge areas of the confined water body. In areas of free ground water, the ground water basin provides regulatory storage to smooth out fluctuations in available water supplies, and changes in ground water storage are indicated by changes in ground water levels.

Data and information collected during the San Joaquin County Investigation indicate that free ground water generally exists in present zones of pumping, although there appears to be some temporary or partial confinement in certain depth zones. Study of historic fluctuations of the water table in the San Joaquin Area, under varying conditions of draft and replenishment, permitted a determination of changes in ground water storage in the basin and its safe yield of water under stated conditions.

Ground Water Geology

Geologic features of the ground water basin underlying the San Joaquin Area were investigated by the Division of Water Resources during the current investigation. A geologic study of the Mokelumne River area, which comprises the northern part of the San Joaquin Area, has been made by the United States Geological Survey, results of which were published in United States Geological Survey Water-Supply Papers 619 and 780.

The San Joaquin Area is located on the gentle alluvial slope at the western base of the Sierra Nevada. This slope has been built up by material carried out of the Sierra Nevada by a number of streams, chief among which are Dry Creek, Mokelumne River, Calaveras River, and Littlejohns Creek. East of the alluvial area the elevations increase, and rocks exposed at the surface generally become older.

Geologic Formations. Geologic formations underlying the San Joaquin Area are summarized in Table 10.

The surface of the pre-Cretaceous igneous and metamorphic rocks dips gently westward in the Sierra Nevada, and this dip continues beneath the younger sediments of the San Joaquin Valley. The sediments of Cretaceous to Recent age thus form a great wedge which is thickest in the center of the valley (near the western boundary of the San Joaquin Area as herein defined), and which feathers out against the crystalline rocks at the eastern edge of the valley (generally a few miles east of the eastern edge of the San Joaquin Area). The post-Eocene sediments yield fresh water to wells in all but the extreme western part of the San Joaquin Area and are therefore of major interest in the present study.

Pre-Cretaceous crystalline rocks, underlying the sediments of the San Joaquin Area at depth and reaching the surface in the Sierra Nevada, are principally metamorphosed sediments and igneous rocks, and unmetamorphosed granitic rocks. Tertiary volcanic rocks, not shown in the above table, also occur. The crystalline rocks are not important for the present study, as in general they neither contain nor transmit large amounts of ground water.

Cretaceous marine sediments of unknown thickness overlie the crystalline basement beneath the San Joaquin Area. Electric logs indicate that these sediments contain only saline waters.

Several Eocene formations have been identified in oil and gas wells in the San Joaquin Area, but these are mostly, if not all, marine and contain poor quality waters. Clay and some sandstone of the Ione formation, in part continental, crop out in places east of the San Joaquin Area, mostly north of the Mokelumne River. Outcrops of an older Eocene formation

TABLE 9

MEASURED AND ESTIMATED SEASONAL SURFACE INFLOW TO AND OUTFLOW FROM SAN JOAQUIN AREA, 1939-40 THROUGH 1951-52

(In acre-feet)

Source	Season													Average for 12-year base period, 1939-40 through 1950-51
	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51	1951-52	
Inflow														
Mokelumne River	734,200	778,000	934,100	998,800	386,200	666,300	645,700	305,100	460,500	408,400	607,300	1,107,000	1,190,200	669,300
Calaveras River [a]	227,500	221,900	217,000	296,800	84,500	166,800	121,100	49,700	82,800	85,200	128,500	328,200	361,800	167,500
Dry Creek	[b]94,200	[b]80,100	[b]141,500	[b]200,100	[b]46,400	[b]119,600	[b]93,100	[b]20,800	[b]43,500	[b]42,500	[a]59,900	[b]213,500	[b]226,800	96,300
Dry Creek (Sacramento County) [b]	6,000	6,000	5,000	6,300	2,200	3,800	1,200	200	300	1,700	2,400	6,600	8,600	3,500
Littlejohns Creek	[b]60,600	[b]61,200	[b]48,500	[a]64,300	[a]38,800	[b]32,600	[a]13,700	[a]12,200	[a]13,000	[a]15,800	[a]34,900	[a]85,800	[a]97,700	40,100
Bear Creek	13,000	13,000	10,800	13,600	4,700	8,100	2,600	400	500	3,700	5,200	14,200	18,400	7,500
Minor drainage [b]	27,000	27,000	22,400	28,200	9,800	16,900	5,400	800	1,000	7,700	10,800	29,500	38,300	15,500
Pumped diversions [b]	18,500	18,600	18,500	18,500	20,700	21,800	23,000	25,200	24,300	25,700	27,200	26,600	33,700	22,400
TOTALS	1,181,000	1,205,800	1,397,800	1,626,600	593,300	1,035,900	905,800	414,400	625,900	590,700	876,200	1,811,400	1,975,500	1,022,100
Outflow														
Mokelumne River	614,900	668,000	832,000	878,500	245,700	524,700	502,200	157,900	317,700	242,200	423,200	902,500	1,034,000	525,800
Calaveras River [c]	0	0	0	0	0	0	0	0	0	3,700	10,200	11,800	35,200	2,100
Stockton Diverting Canal	[b]208,600	[b]203,000	[b]198,000	[b]275,000	77,900	153,800	109,000	38,200	68,000	60,500	87,100	307,000	294,300	148,800
Dry Creek	[b]92,000	[b]77,000	[b]142,200	208,500	41,700	115,300	84,400	14,000	35,000	51,600	60,800	237,900	229,700	96,700
Bear Creek [b]	26,700	26,200	22,800	23,200	6,600	11,300	3,600	600	700	5,200	14,300	24,000	31,500	13,200
Duck Creek	[b]5,200	[b]5,200	[b]4,600	[b]6,000	[b]1,600	[b]3,300	[b]600	[b]0	[b]0	[a]1,100	1,900	6,800	7,900	3,000
French Camp Slough	[b]52,100	[b]41,500	[b]46,000	[b]76,200	[b]31,200	[b]32,600	[b]15,100	[b]10,400	[b]18,800	[b]18,200	[a]33,100	91,200	77,300	38,900
Woodbridge Irrigation District [d]	[b]22,900	[b]23,300	[b]22,400	[b]25,900	[b]30,000	[b]28,400	[b]30,400	[b]29,600	[b]27,800	[b]33,000	[b]37,200	[b]29,500	28,500	28,400
Unmeasured outflow [b]	7,000	6,200	6,700	5,900	3,900	3,700	3,000	0	1,700	4,400	2,100	8,600	8,300	4,400
Reclamation pumps [b]	9,800	15,900	10,600	9,300	4,300	5,900	7,300	10,400	5,500	7,000	7,100	10,000	10,500	8,600
TOTALS	1,038,600	1,066,300	1,285,300	1,508,500	442,900	879,000	755,600	261,100	475,200	426,900	670,000	1,629,300	1,757,200	869,900

[a] Partially estimated.
[b] Estimated.
[c] Includes North Slough.
[d] Woodbridge Irrigation District outflow was measured at 25 stations in 1952. Station locations are shown on Plate 2 and records are included in Appendix D.

TABLE 10

GEOLOGIC FORMATIONS UNDERLYING SAN JOAQUIN AREA

Age	Formation	Range of thickness, in feet
Recent	Alluvium	0–25
Pleistocene	Victor formation	0–125
Pleistocene	Arroyo Seco gravel	0–1,200
Plio (?)-Pleistocene	Laguna formation	
Miocene and/or Pliocene	Mehrten formation	75–550
Miocene	Valley Springs formation	75–525
Eocene	Various formations at depth; Ione principal formation on outcrop	75–4,000?
Cretaceous	Formations at depth; no outcrop	?
Pre-Cretaceous	Igneous and metamorphic rocks	--------

have also been reported. The permeability of the Eocene formations is generally low.

The Valley Springs formation crops out in an area lying a few miles east of the San Joaquin Area. It is composed principally of pumice, rhyolitic volcanic ash, and clay, but contains some sand and conglomerate. The formation generally contains good quality water in the eastern part of the San Joaquin Area, but its permeability is low and it does not yield much water to wells.

The Mehrten formation occurs at the surface in an irregularly shaped area lying just west of the outcrop belt of the Valley Springs formation. Although much of this area lies east of the San Joaquin Area, it is important as an intake area for Mehrten aquifers underlying the San Joaquin Area itself.

The Mehrten formation is principally made up of siltstone, sandstone, and conglomerate. It also contains some beds of unconsolidated sand and some layers of volcanic agglomerate probably derived from mudflows. "Black sands" reported from wells extending into the Mehrten formation are so called because of their high content of andesitic grains. The thickness of the formation in the Mokelumne River area varies from 75 to 400 feet. This thickness appears to increase southward and westward. The formation dips a little less than 100 feet per mile in a direction slightly south of west in most of the San Joaquin Area, as shown on Plate 7, entitled "Geologic Cross Section."

Many of the sands of the Mehrten formation are highly permeable, and furnish water to deep wells in the eastern part of the San Joaquin Area. The Mehrten aquifers receive percolation from the Mokelumne River for about three miles east of Clements, from the Calaveras River between one mile west of Bellota to five miles east of Bellota, from Farmington Reservoir on Littlejohns Creek, and from numerous small streams in the area of outcrop.

Some wells produce large quantities of water from the Mehrten formation. Well 1N/9E-13A1, located about three miles east of Farmington and drilled from near the top of the Mehrten formation to a depth of about 650 feet, is reported to produce between 1,200 and 1,350 gallons per minute, most or all of which undoubtedly comes from the Mehrten formation.

Irrigation wells in the Calaveras alluvial fan east of Jack Tone Road are almost always drilled through at least one stratum of "black sand" in order to produce sufficient water. Both the composition and stratigraphic position of these black sands show that they occur most commonly in the Mehrten formation, although a few, composed perhaps of re-worked Mehrten detritus, are present in the overlying Laguna formation. A contour map shown in United States Geological Survey Water-Supply Paper 780, which shows elevations of the top of the Mehrten formation, can be used to determine the approximate stratigraphic position of any given black sand by comparing its elevation with that of the top of the Mehrten. The black sands encountered by wells at depths of about 300 to about 450 feet in the Linden district appear to be in the central part of the Mehrten formation, and those in the vicinity of Jack Tone Road at depths of 400 to 550 feet are apparently near its top. A black sand examined from a well near the center of the town of Linden was a moderately well-rounded, moderately well-sorted, medium- to fine-grained sand composed largely of grains of metamorphic and volcanic rocks. Andesite and basalt grains appeared to be the principal volcanic types. It is reported that many wells drawing from black sand aquifers have specific capacities in excess of 100. Specific capacity refers to the number of gallons of water per minute produced by a pumping well per foot of drawdown. Drawdown, in turn, refers to the lowering of the water level in a well caused by pumping, measured in feet.

West of the outcrop area, water in the Mehrten aquifers is partially confined by relatively impervious strata higher in the formation and in the overlying Laguna formation. The water level of wells in the Mehrten formation, however, appears to be little different from that of nearby shallower wells.

The Laguna formation underlies the area of gently rolling topography between the outcrop area of the Mehrten formation and the more recent sediments of the alluvial plain of the San Joaquin Valley. The Laguna formation is largely composed of stream-laid sand and silt, but it contains some gravel and clay. Its composition varies markedly both vertically and laterally. The formation dips westward throughout most of the San Joaquin Area and is in essential conformity with the underlying Mehrten formation, but it appears to thicken notably to the west. Its thickness in the Mokelumne River area is given by the United State Geological Survey as 0-400 feet, but greater thicknesses of sediments of Laguna age must be present at depth west of the area of outcrop.

Evidence concerning the age of the Laguna formation was found during field work for the present investigation by the discovery of three fossil horse teeth. In March, 1950, a tooth was found at a depth of 198 feet during drilling of well 1S/8E-2M2, owned by L. Malakas. Two other teeth were found by geologists of the Division of Water Resources during examination of a road cut on the Valley Home-Cometa Road, in the northeast quarter of Section 14, Township 1 South, Range 9 East, M. D. B. & M. The latter two specimens were found in a clayey silt mapped as part of the Laguna formation. All three specimens were identified by D. E. Savage, curator of the Museum of Paleontology of the University of California at Berkeley. Specimen No. 1 from the Malakas well was identified as a lower molar not earlier than late Pliocene and possibly early Pleistocene. Specimen No. 2, a tooth fragment, and Specimen No. 3, were identified, respectively, as an upper molar and a lower milk premolar. Both teeth were from a Pleistocene horse.

The evidence on the age of the Laguna formation given by these teeth agrees in general with the age as given in United States Geological Survey Water-Supply Paper 780, where the Laguna is described as "laid down presumably in Pliocene, but perhaps in early Pleistocene time." The Malakas tooth, believed from its position to be from deposits of Laguna age, could be either Pliocene or Pleistocene; but the other two teeth indicate a Pleistocene age for at least part of the Laguna formation.

The hydrologic characteristics of the Laguna formation are variable. Bodies of perched water are common in its outcrop areas. Farther west, certain sands in the Laguna formation yield water to wells in sufficient quantity for irrigation, and several wells having yields in excess of 2,000 gallons per minute bottom in the Laguna formation and obtain much of their yield from it. Water-bearing yellow sands and gravels reached at depths in the vicinity of 200 feet just west of Jack Tone Road between the Calaveras River and Mormon Slough are in all probability in the Laguna formation, and so are deeper water-bearing gray and reddish sands. The specific capacity of wells in the yellow sand is reported to be generally on the order of 50.

Well logs indicate that numerous strata of blue clay occur in the Laguna formation beneath the western part of the area under consideration. The log of well 1N/6E-12F2, for example, drilled to a depth of 1,042 feet for the California Water Service Company in Stockton, shows alternating strata of blue clay and various types of sand between 120 feet and the bottom of the hole. One stratum of red clay is recorded in this interval. In the area between the Calaveras River and Mormon Slough, no blue clays have been reported east of Alpine Road, but farther south blue clays appear in the logs of wells 1S/9E-9F1 and 1S/9E-5R1, located near the end of Skiff Road on either side of the Escalon-Bellota Road. Pressure effects are generally marked in wells which penetrate blue clay.

The Arroyo Seco gravel is a thin unit lying between the Laguna and Victor formations. On the outcrop it is made up of weathered cobbles, sand, and gravel. The formation is believed to have once covered an extensive pediment, part of which is now buried beneath the Calaveras and Mokelumne River alluvial fans. Like the Laguna formation, the Arroyo Seco is believed to thicken westward underground. Sediments of Arroyo Seco age undoubtedly yield water to some wells, but such sediments cannot be differentiated in logs from underlying and overlying formations.

Patches of gravel both older and younger than the Arroyo Seco occur east of the San Joaquin Valley alluvial plain. They have no hydrologic significance.

The name Victor formation was given by the authors of United States Geological Survey Water-Supply Paper 780 to deposits in parts of the alluvial plains of the San Joaquin Area where alluvium is not now actively accumulating, or would not be under normal conditions. Deposits on either side of the trench of the Mokelumne River, for example, belong to the Victor formation since the Mokelumne is entrenched and can no longer lay down alluvial deposits by flooding the surrounding areas. Farther south, however, streams such as the Calaveras River and Littlejohns Creek flooded extensive areas under natural conditions before construction of presently existing levees and dams. Therefore, deposits of Victor age are there buried under a mantle of Recent alluvium. The age of the Victor deposits is given in Water-Supply Paper 780 as Pleistocene, and their thickness as 0 to 125 feet.

The Victor formation is composed of sands, gravels, silts, and clays. It was laid down by the various streams debouching from the Sierra Nevada depositing material on their growing alluvial fans. The sand and gravel stringers in the Victor formation represent active channels of the distributaries in which the coarser sediments were deposited. Silt and clay deposits represent areas between the active distributaries, areas in which deposits were made only at times of flood. The position of the active channels shifted continually during the process of building of the alluvial fans, and an interfingering network of sand and gravel stringers has resulted.

Although most irrigation wells in the San Joaquin Area obtain their water principally or entirely from strata below the Victor formation, a number of wells obtain large yields mainly or entirely from Victor sediments. Several wells located a few miles south of Stockton and west of U. S. Highway 99 reportedly yield in excess of 2,200 gallons per minute. Two of these wells, 1N/7E-32P1 and 1N/7E-32P2, are less than 200 feet deep and may obtain a large portion of their yield from sediments of the Victor formation.

Sands, gravels, silts, and clays in active stream channels, and silts and clays in areas subject to flooding, compose the Recent alluvium. These deposits generally transmit water to underlying permeable formations, although, except in stream channels, the Recent deposits themselves are generally above the water table.

Structure. Throughout most of the San Joaquin Area, surface and sub-surface deposits from Valley Springs to Arroyo Seco in age dip a few degrees south of west at a gentle angle. This dip is believed to be due to tilting of the Sierra Nevada block just prior to and during Arroyo Seco time. Sediments of the Victor formation, deposited on the Arroyo Seco pediment, are essentially flat-lying.

Incomplete information from petroleum geologists reveals that an arch disturbs the regional dip in the southern part of the San Joaquin Area, south of a fault believed to lie about two and one-half miles south of Stockton and to trend about N. 60° E. The trend of the axis of this arch appears to be northwesterly, in conformity with the regional strike.

Movement of Ground Water. Ground water enters all the water-bearing formations of the San Joaquin Area by percolation of water from surface streams in the outcrop areas of the formations, by rainfall penetration, and by percolation of unconsumed water supplies on irrigated lands.

Movement of ground water is in a general westerly direction throughout most of the San Joaquin Area. A marked cone of depression exists under the area of the City of Stockton, and water moves toward the center of this cone from all directions. Direction of ground water movement is perpendicular to the contours of ground water elevation as shown on Plate 9, "Lines of Equal Elevation of Ground Water, Fall of 1952."

Specific Yield and Ground Water Storage Capacity

The term "specific yield," when used in connection with ground water, refers to the ratio of the volume of water a saturated soil will yield by gravity to its own volume, and is commonly expressed as a percentage. Ground water storage capacity is estimated as the product of the specific yield and the volume of material in the depth intervals considered.

During studies of the ground water basin of the San Joaquin Area, specific yield of different depth zones was estimated after analyzing some 300 well logs. The estimates were based on previously determined characteristics of the various types of material classified in the well logs. Such characteristics of various types of material are set forth in State Water Resources Board Bulletin No. 1. Ground water storage capacity of the San Joaquin Area was determined for depth intervals from 25 to 50 feet, 50 to 75 feet, 75 to 100 feet, 100 to 125 feet, 125 to 150 feet, 150 to 175 feet, 175 to 200 feet, and for the entire interval from 25 to 200 feet below ground surface. However, in an area of saline ground water centered under the City of Stockton in the western portion of the Calaveras Unit and encompassing about 10,000 acres, where storage capacity below a depth of 100 feet was considered not usable under present conditions, the determination was limited to the 25- to 100-foot depth interval. Also, well logs indicating the type of material below a depth of 150 feet were not available in the Western Mokelumne

TABLE 11

ESTIMATED SPECIFIC YIELD AND GROUND WATER STORAGE CAPACITY IN UNITS OF SAN JOAQUIN AREA

Depth interval, in feet from ground surface	Weighted average specific yield, in per cent				Ground water storage capacity, in acre-feet				
	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit	Total
25-50	6.8	7.1	5.8	7.0	125,000	196,000	125,000	166,000	612,000
50-75	6.5	8.2	6.7	6.9	119,000	226,000	144,000	163,000	652,000
75-100	5.7	6.5	7.2	7.1	105,000	180,000	155,000	168,000	608,000
100-125	5.8	7.7	6.8	7.2	107,000	213,000	129,000	170,000	619,000
125-150	6.0	7.4	7.6	6.9	110,000	204,000	144,000	163,000	621,000
150-175	---	9.2	6.6	7.1	------	254,000	126,000	168,000	548,000
175-200	---	7.1	7.2	6.9	------	196,000	137,000	163,000	496,000
25-200	6.2	7.6	6.6	7.0	566,000	1,469,000	960,000	1,161,000	4,156,000

Unit and, therefore, estimates of ground water storage capacity in that unit were limited to 150 feet of depth. Storage capacity of the ground water basin underlying the San Joaquin Area and the estimated weighted average specific yield are shown in Table 11 by units of the area.

Ground Water Levels

Records of ground water levels in the San Joaquin Area date back to 1906 when the United States Geological Survey made a study of ground water in the San Joaquin Valley. Periodic records of ground water levels since that time are available from intermittent well measurement programs conducted in various portions of the San Joaquin Area by several interested agencies. Available historical data indicate that a cone of depression in the water table existed prior to 1931 in a zone centered under the City of Stockton in an area of heavy pumping draft. The elevation of the water table at the center of the depression cone averaged about 10 feet below mean sea level in the fall of 1931, and has lowered during recent years, as pumping draft increased, to an elevation of about 40 feet below sea level in the fall of 1952.

A list of those agencies which have obtained records of well measurements in the San Joaquin Area prior to the San Joaquin County Investigation is presented in Table 12, together with approximate number of wells measured, frequency of measurement, periods of record, and the unit of the area in which the measurements were made.

In addition to the foregoing, the Pacific Gas and Electric Company has obtained measurements of depth to ground water at a large but undetermined number of wells in units of the San Joaquin Area since 1930 in connection with its well pump testing program.

A complete series of measurements of static ground water levels at approximately 730 wells in the San Joaquin Area was made in the spring and fall of each year during the period of investigation, beginning in the fall of 1947 in the Calaveras Unit, fall of 1948 in the Eastern and Western Mokelumne Units, and fall of 1949 in the Littlejohns Unit. These measurements were continued into 1954. In addition,

TABLE 12

GROUND WATER MEASUREMENTS AVAILABLE IN SAN JOAQUIN AREA PRIOR TO SAN JOAQUIN COUNTY INVESTIGATION

Agency making well measurements	Approximate number of wells measured	Frequency of measurement	Period of record	Unit in which measurements were made
United States Geological Survey	[a]70	Annually	1906-07	Western Mokelumne and Eastern Mokelumne
	[b]90	Annually	1913-14	Western Mokelumne and Eastern Mokelumne
	[c]500	Monthly	April, 1926 to April, 1927	Western Mokelumne, Eastern Mokelumne, and Calaveras
	[c]80	Monthly to semiannually	1926-29	Western Mokelumne, Eastern Mokelumne, and Calaveras
State Division of Water Resources	300	Semiannually	1926-32	Western Mokelumne, Eastern Mokelumne, Calaveras, and Littlejohns
	15	Annually	1929-40 and 1947-54	Western Mokelumne, Eastern Mokelumne, and Calaveras
East Bay Municipal Utility District	40	Monthly	1925-54	Western Mokelumne, Eastern Mokelumne, and Calaveras
	190	Semiannually	1925-54	Western Mokelumne, Eastern Mokelumne, and Calaveras
	70	Annually	1925-54	Western Mokelumne, Eastern Mokelumne, and Calaveras
Linden Irrigation District	40	Semiannually	1926-40	Calaveras
Federal Land Bank of Berkeley	20	One measurement	August, 1947	Calaveras
United States Bureau of Reclamation	90	Quarterly	1946-50	Western Mokelumne, Eastern Mokelumne, Calaveras, and Littlejohns
California Water Service Company	20	Monthly	1931-54	Calaveras
City of Stockton	70	Annually	1926-36	Western Mokelumne, Calaveras, and Littlejohns
City of Lodi	25	Annually	1930-54	Western Mokelumne and Eastern Mokelumne

[a] Published in U.S.G.S. Water-Supply Paper 398.
[b] Published in U.S.G.S. Water-Supply Paper 495.
[c] Published in U.S.G.S. Water-Supply Paper 619.

monthly measurements were made at approximately 130 control wells, comprising 55 wells measured during 1948 and 1949 in the Calaveras Unit, 40 wells measured during 1949 and 1950 in the Eastern and Western Mokelumne Units, and 35 wells measured during 1950 and 1951 in the Littlejohns Unit. The purpose of these monthly measurements was to observe behavior of the ground water table under conditions of draft and recharge. Available unpublished records of depth to ground water at wells in the San Joaquin Area are included as Appendix E to this bulletin.

Depths to ground water throughout the San Joaquin Area, as measured during the fall of 1952, were plotted on a map and lines of equal depth drawn. This is shown on Plate 8, entitled "Lines of Equal Depth to Ground Water, Fall of 1952." Plate 9, "Lines of Equal Elevation of Ground Water, Fall of 1952," was prepared from data used for Plate 8, depths to ground water being subtracted from elevations of the measuring points above sea level to obtain elevations of the water table.

Table 13 shows depths from ground surface to the water table at selected wells in the several units of the San Joaquin Area during the fall of most years from 1926 through 1952. The measurements were made following the summer period of irrigation pumping draft and prior to recovery of ground water storage resulting from winter rains. The wells are numbered by the system utilized by the United States Geological Survey in Water-Supply Papers 619 and 780, according to township, range, and section. Under this system each section is divided into 40-acre plots which are lettered as follows:

A	B	C	D
E	F	G	H
J	K	L	M
N	P	Q	R

Wells are numbered within each of these 40-acre plots according to the order in which they are located. For example, a well having a number 3N/6E-24A2

TABLE 13

MEASURED FALL DEPTHS TO GROUND WATER AT REPRESENTATIVE WELLS IN UNITS OF SAN JOAQUIN AREA

(In feet)

Year	Western Mokelumne Unit			Eastern Mokelumne Unit			Calaveras Unit			Littlejohns Unit	
	Well number										
	2N/6E-3A1	3N/5E-13D1	4N/5E-11J1	3N/6E-2P2	3N/7E-17D2	4N/7E-7H1	1N/6E-12B1	2N/7E-12D2	2N/8E-18D1	1N/7E-12R1	1N/9E-31F1
1926	10.8	12.1	9.0	14.7	29.3	28.0	----	[b]32.0	31.0	6.7	19.6
1927	10.6	11.9	7.5	14.5	29.5	28.9	----	[b]33.5	32.0	6.4	17.4
1928	11.2	13.1	5.6	15.6	30.7	29.9	----	[b]34.0	33.8	6.6	16.9
1929	12.2	12.7	8.3	17.0	32.5	31.7	----	35.5	32.5	7.0	17.1
1930	12.4	12.6	9.5	17.1	33.7	32.9	----	37.5	35.0	----	----
1931	13.9	13.6	7.3	18.0	35.9	34.7	38.4	39.5	38.1		----
1932	12.5	12.8	7.2	17.2	35.4	35.0	34.6	40.8	44.2	7.4	17.8
1933	13.8	----	7.2	17.6	36.4	36.0	36.3	41.5	42.8	----	----
1934	12.7	----	6.0	18.2	36.8	37.5	36.4	43.5	40.1	----	----
1935	9.2	----	6.8	17.3	36.8	37.8	38.0	[b]42.1	40.7	----	----
1936	8.4	----	5.9	16.4	34.6	37.2	39.0	42.8	39.2	----	----
1937	5.9	10.0	5.6	16.0	32.7	35.9	34.2	41.2	38.1	----	----
1938	7.2	11.2	5.6	14.8	31.0	34.6	34.5	37.0	34.2	----	----
1939	6.9	12.0	6.4	17.9	34.5	37.7	41.2	[b]41.2	----	----	----
1940	6.6	9.5	5.5	17.1	33.5	38.1	42.6	40.3	----	----	----
1941	5.7	8.8	4.7	15.3	32.1	36.3	43.1	----	----	----	----
1942	5.3	8.4	4.8	14.8	31.2	35.6	35.5	----	----	----	----
1943	4.6	9.2	4.8	14.0	31.5	34.9	36.6	----	----	----	----
1944	8.5	9.3	5.1	16.6	34.2	37.5	37.8	----	----		20.0
1945	6.7	9.6	4.3	17.3	36.0	39.6	48.4	----	----	7.6	22.0
1946	[d]8.0	10.2	4.3	18.6	37.5	----	48.0	[b]50.4	46.7	8.0	26.3
1947	[d]11.5	11.4	5.5	20.4	39.7	[a]47.4	44.0	51.1	50.2	7.5	24.4
1948	[d]13.3	10.5	6.4	23.3	40.8	[a]50.0	56.0	53.7	53.2	9.9	34.7
1949	[d]10.8	11.1	6.6	19.5	41.2	[a]52.3	----	57.0	57.5	10.2	41.5
1950	[d]11.6	10.9	4.7	21.2	43.1	[a]53.6	58.0	57.4	57.1	14.1	43.9
1951	[d]10.4	10.9	6.2	19.3	41.2	[a]55.1	59.0	57.6	58.9	13.6	[c]47.5
1952	[d]12.0	10.9	5.2	18.5	39.3	[a]53.1	63.0	56.4	56.5	14.8	[c]49.8

[a] Well No. 4N/7E-H2.
[b] Well No. 2N/7E-1R1 (500 feet north of Well No. 2N/7E-12D2).
[c] Well No. 1N/9E-31H1.
[d] Well No. 2N/6E-3A11.

would be found in Township 3 North, Range 6 East, and in Section 24. It would be further identified as the second well located in the 40-acre plot lettered A. Fluctuations in depth to ground water at a representative well in each unit of the San Joaquin Area are depicted graphically on Plate 10, entitled "Measured Fall Depths to Ground Water at Representative Wells."

From a study of all available well measurements, estimates were made of the approximate average depth to ground water in each of the four units of the San Joaquin Area in the fall of each year from 1926 through 1952. These averages, which constitute arithmetical averages of available measurements, are presented in Table 14, and are illustrated graphically on Plate 11, entitled "Estimated Average Fall Depth to Ground Water."

TABLE 14

ESTIMATED AVERAGE FALL DEPTH TO GROUND WATER IN SAN JOAQUIN AREA

(In feet)

Year	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit
1926	8.4	43.3	25.7	18.8
27	7.7	43.3	26.7	18.4
28	8.5	44.2	27.7	18.6
29	9.1	45.7	28.9	19.9
1930	8.7	46.4	31.3	----
31	9.5	48.1	32.7	----
32	8.7	48.2	33.1	20.6
33	8.9	49.2	35.1	----
34	8.3	49.7	36.2	22.2
1935	7.9	49.7	36.4	21.5
36	7.6	48.6	36.0	22.1
37	7.2	47.7	34.9	21.9
38	7.2	46.4	31.7	21.5
39	8.9	48.9	34.2	21.0
1940	8.0	48.7	34.1	20.0
41	7.5	47.6	34.4	----
42	7.6	47.1	34.9	----
43	7.6	46.9	37.0	----
44	8.3	48.9	39.1	----
1945	8.4	50.0	39.8	23.1
46	8.9	51.5	41.7	24.9
47	10.3	52.1	43.3	26.6
48	10.2	55.7	46.2	28.9
49	10.5	57.0	49.3	31.7
1950	10.3	58.1	50.6	34.0
51	9.8	58.4	51.1	35.0
52	9.0	58.1	50.0	37.5

Data presented in Table 14 indicate a general moderate lowering of the water table over the San Joaquin Area from 1926 to 1934, with exception of the Western Mokelumne Unit in which ground water levels showed little change. This series of dry years was brought to an end in 1935, and ground water levels throughout the San Joaquin Area rose during a generally wet series of years until 1938, at which time the depth to ground water was the least during the period from 1930 through 1952. A deficient water supply season in 1939 caused a rather sharp decline in ground water levels throughout the area, with the exception of the Littlejohns Unit where irrigated agriculture had not yet developed to any appreciable extent. Levels again exhibited a rise during the wet years from 1940 until 1943. A series of dry years since 1943, coincidental with expansion and intensification of irrigated agriculture, has resulted in a continued lowering of the water table until the fall of 1951 when the water table reached its greatest average depth of record. Units of the San Joaquin Area showed a rise in ground water levels from 1951 to 1952, with exception of the Littlejohns Unit which suffered a continued lowering caused by the recent and rapid increase in irrigated agriculture supplied from ground water.

In order to estimate weighted average changes in ground water elevations in the San Joaquin Area during the 12-year base period and in each investigational season, maps were drawn showing lines of equal change in elevation during these periods. Examples of these maps are presented as Plate 12, entitled "Lines of Equal Change in Ground Water Elevation From Fall of 1939 to Fall of 1951," and Plate 13, entitled "Lines of Equal Change in Ground Water Elevation From Fall of 1949 to Fall of 1952." By planimetering the areas between lines of equal change, the weighted average change in elevation of water levels was estimated for each unit of the San Joaquin Area. The results of these estimates are presented in Table 15.

TABLE 15

ESTIMATED WEIGHTED AVERAGE SEASONAL CHANGES IN FALL GROUND WATER ELEVATION IN UNITS OF SAN JOAQUIN AREA

(In feet)

Unit	1939-40 to 1950-51	1949-50	1950-51	1951-52
Western Mokelumne	—0.06	+0.2	+0.5	+0.8
Eastern Mokelumne	—0.79	—1.1	—0.3	+0.3
Calaveras	—1.41	—1.3	—0.5	+1.0
Littlejohns	—1.17	—2.3	—1.0	—2.6

Change in Ground Water Storage

In an area of free ground water, the volume of soil unwatered or resaturated over a period of time, when multiplied by the specific yield, measures the change in ground water storage during that time. Available data on fluctuations of water levels at wells in the San Joaquin Area were sufficient to estimate the volume of soil unwatered or resaturated during the base period, and during the investigational seasons. Changes in ground water storage were estimated for each unit of the area by multiplying changes in elevation of ground water, presented in Table 15, by the area of each unit, and by the derived average

TABLE 16

ESTIMATED WEIGHTED AVERAGE SEASONAL CHANGES IN GROUND WATER STORAGE IN UNITS OF SAN JOAQUIN AREA

(In acre-feet)

Unit	Area, in acres	Weighted average specific yield, in per cent	1939-40 to 1950-51	1949-50	1950-51	1951-52
Western Mokelumne	73,470	6.2	—300	+900	+2,300	+3,600
Eastern Mokelumne	110,800	7.3	—6,400	—8,900	—2,400	+2,400
Calaveras	85,970	6.1	—7,400	—6,800	—2,600	+5,200
Littlejohns	94,460	6.6	—7,300	—14,300	—6,200	—16,200
TOTALS	364,700		—21,400	—29,100	—8,900	—5,000

value of specific yield for the depth interval unwatered in each unit during the base period and the investigational seasons. The results of these estimates are presented in Table 16.

It will be noted in Table 16 that the weighted specific yields of the depth intervals unwatered in the Calaveras and Littlejohns Units are less than the weighted specific yields for the 25-foot depth intervals indicated in Table 11 for these units. The reason for this is that the unwatered depth occurring during the period 1939-40 through 1951-52 in the Calaveras and Littlejohns Units, and limited to a few feet, was in less permeable material than that indicated from the determination of the weighted specific yield over a depth interval of 25 feet.

The estimates presented in Table 16 indicate that an average seasonal net decrease in ground water storage in the San Joaquin Area of 21,400 acre-feet occurred during the 12-year base period, in which conditions of water supply and climate were approximately equivalent to conditions during the mean period. The estimated net decrease in ground water storage during the investigational seasons was about 29,000 acre-feet in 1949-50, about 9,000 acre-feet in 1950-51, and about 5,000 acre-feet in 1951-52. It may be noted that the decrease in storage during the base period was generally equally distributed between the Eastern Mokelumne, Calaveras, and Littlejohns Units, but that the decrease in storage during the investigational seasons occurred principally in the Littlejohns Unit where pumping draft for irrigation has increased markedly in recent years. In the Western Mokelumne Unit which lies along the fringe of the Delta, ground water levels did not fluctuate materially and changes in ground water storage were of minor importance.

Subsurface Inflow and Outflow

Lines of equal elevation of ground water in the San Joaquin Area in the fall of 1952 are shown on Plate 9. Slopes of the water table as defined by these ground water contours, together with information on the permeabilities of the various subsurface geologic formations, indicate that nearly all the subsurface inflow to the area came from the east and southeast. Minor quantities of subsurface inflow from the Delta probably occur in the Stockton area.

The ground water gradients shown on Plate 9 indicate that there was no subsurface outflow from the San Joaquin Area during the 1952 season except from the Western Mokelumne Unit. These conditions probably prevailed during the base period, even in wetter seasons such as those from 1940 to 1943, because ground water levels in the Western Mokelumne Unit, which was the only area with a water table slope toward the Delta, remained essentially constant during that period.

The ground water contours shown on Plate 9 indicate the presence of a depression cone in the water table centered under the City of Stockton during 1952. The relatively steep slope of the water table around the perimeter and toward the center of this cone has resulted from the heavy industrial and municipal pumping draft on the aquifers for the City of Stockton. This ground water depression cone has existed perennially through the 12-year base period, and has substantially eliminated subsurface outflow from the investigational area to the Delta.

An indirect method was used to estimate the net effect of subsurface inflow to and outflow from the San Joaquin Area. This involved evaluation of the difference between subsurface inflow and outflow as the item necessary to effect a balance between water supply and disposal. The sum of the items comprising the water supply of a given hydrologic unit or area must be equal to the sum of the items of water disposal. In the case of the San Joaquin Area, values for pertinent items other than the difference between subsurface inflow and outflow, including surface inflow and outflow, precipitation, change in ground water storage, and consumptive use of water, were quantitatively measured or estimated. Determination of values for consumptive use of water is explained in Chapter III. Retention of subsurface inflow, or the difference between subsurface inflow and outflow, was the remaining unknown quantity to balance supply and disposal. Table 17 sets forth this equation for the San Joaquin Area.

Ground Water Pumping Well in San Joaquin Area

TABLE 17

ESTIMATED EXCESS OF SEASONAL SUBSURFACE INFLOW OVER SUBSURFACE OUTFLOW IN UNITS OF SAN JOAQUIN AREA

(In acre-feet)

Item	Average for 12-year base period, 1939-40 through 1950-51				Average for 3-year period, 1949-50 through 1951-52			
	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit
Water supply								
Precipitation	91,000	153,000	112,000	112,000	101,600	171,300	124,900	122,900
Surface inflow	131,700	779,900	172,700	51,300	153,800	1,158,500	281,100	91,000
Decrease in ground water storage	300	6,400	7,400	7,300	+2,300	3,000	1,400	12,200
TOTALS	223,000	939,300	292,100	170,600	253,100	1,332,800	407,400	226,100
Water disposal								
Surface outflow	37,000	753,800	150,900	41,900	39,700	1,122,300	248,500	72,700
Consumptive use of water	170,000	195,800	177,000	145,600	181,100	220,500	194,400	204,800
TOTALS	207,000	949,600	327,900	187,500	220,800	1,342,800	442,900	277,500
REMAINDER—EXCESS OF SUBSURFACE INFLOW OVER SUBSURFACE OUTFLOW	*—16,000	10,300	35,800	16,900	*—32,300	10,000	35,500	51,400

* Slopes of the water table indicate that there is little subsurface inflow to the Western Mokelumne Unit. Replenishment to ground water is attributed principally to surface inflow to that unit. The values presented, therefore, indicate the amount of subsurface outflow from the unit.

Certain of the values presented in Table 17 are of large magnitude as compared to the derived excess of subsurface inflow over subsurface outflow. Small percentage errors in these larger quantities might introduce relatively large errors in the derived remainders. However, possible large errors manifest in such a derivation for a single season are largely eliminated over a relatively long period, such as the 12-year base period, and were minimized by selection of a 3-year period, 1949-50 through 1951-52, for studies to evaluate present subsurface inflow.

Yield of Wells

Yield of wells is an important factor in the use of ground water in the San Joaquin Area. Wells of adequate capacity for irrigation purposes can generally be obtained throughout the area. Yield of wells was analyzed, utilizing data obtained from well pumping tests made by the Pacific Gas and Electric Company during the period from 1946 through 1953. Results of the analysis, on wells tested within recent years having higher discharges and specific capacities than average wells in the area, are presented in Table 18, which shows for each unit of the San Joaquin Area the number of tested wells selected, and their average discharge and specific capacity. As heretofore mentioned, the term "specific capacity" refers to the number of gallons of water per minute produced by a pumping well per foot of drawdown. "Drawdown" refers to the lowering of the water level in a well caused by pumping, and is measured in feet.

TABLE 18

ESTIMATED AVERAGE YIELD OF SELECTED WELLS IN UNITS OF SAN JOAQUIN AREA

Unit	Number of wells tested	Average discharge, in gallons per minute	Average specific capacity, in gallons per minute per foot of drawdown
Western Mokelumne	57	1,340	85
Eastern Mokelumne	131	1,080	68
Calaveras	111	1,560	83
Littlejohns	98	1,840	88

Safe Ground Water Yield

The term "safe ground water yield" refers to the maximum rate of extraction of water from a ground water basin which, if continued over an indefinitely long period of years, would result in the maintenance of certain desirable fixed conditions. Commonly, safe ground water yield is determined by one or more of the following criteria:

1. Mean seasonal extraction of water from the ground water basin does not exceed mean seasonal replenishment to the basin.

2. Water levels are not so lowered as to cause harmful impairment of the quality of the ground water by intrusion of other water of undesirable quality, or by accumulation and concentration of degradants or pollutants.

3. Water levels are not so lowered as to imperil the economy of ground water users by excessive costs of pumping from the ground water basin, or by exclusion of users from a supply therefrom.

Safe ground water yield, as derived in this bulletin, was measured by net extraction of water from the San Joaquin Area ground water basin, as differentiated from total pumpage from the basin. Since the San Joaquin Area overlies a free ground water basin, the unconsumed portion of total pumpage may return to the ground water basin and become available for re-use. The net rate of extraction, therefore, was considered to be only that portion of total pumpage from the ground water basin which was consumptively used.

Under natural conditions, ground water is expended by consumptive use from seep lands and from lands where the water table is close to the ground surface, by effluent stream flow, and by subsurface outflow. Artificial development and utilization of ground water salvages all or a portion of such natural disposal, by lowering ground water levels. This, in turn, affords opportunity for additional replenishment of ground water.

With the present general patterns of water utilization in the San Joaquin Area, extraction of water from the ground water basin might be increased. Such increase in draft would undoubtedly be accompanied by recession of ground water levels in areas of pumping, as has been evidenced during the past few years. This lowering of the water table would induce increased subsurface inflow to the areas of pumping and reduce natural disposal of the ground water, the probable effect of which would be to increase replenishment and thereby increase safe ground water yield. However, such increased subsurface inflow and replenishment from adjacent areas, induced by lowering of the water table in the San Joaquin Area, is limited, and it is doubtful that ground water levels would stabilize under continuation of the present rate of pumping draft without resulting in an unreasonable further lowering of the water table. Moreover, seasonal pumping draft on the ground water basin has been increasing considerably during recent years, and will probably continue to increase, thereby causing a continued and probably permanent recession of ground water levels. Therefore, under the assumption that present ground water levels are desirable, the first of the foregoing criteria for determination of safe yield would be applicable in the San Joaquin Area.

Because of the threat of deterioration in mineral quality of the ground water in the intensively pumped areas immediately west of Stockton, and in other isolated areas along the western edge of the Littlejohns and Western Mokelumne Units, the second of the foregoing criteria for determination of safe ground water yield may be applicable to the San Joaquin Area at some time in the future. If the present trend of progressive lowering of ground water levels should continue, the third of the foregoing criteria would also apply. However, such is not presently the case.

As previously stated, consumptive use of ground water was considered to be equal to net extraction of water from the ground water basin of the San Joaquin Area. Safe ground water yield was derived as the difference between the water supply available to meet total consumptive use requirements and the sum of consumptive use of precipitation and applied surface water, under present development and mean conditions of water supply and climate. The water supply available to meet present total consumptive use requirements was taken from data presented in Table 17 for the 12-year base period, with certain corrections to surface inflow and outflow to adjust to present conditions. Estimates of average seasonal consumptive use of precipitation and applied surface water are presented and explained in Chapter III. The difference between the water supply available to meet total consumptive use and the estimated seasonal consumptive use of precipitation and applied water represents the water supply available to meet the consumptive use requirements of applied ground water, or the safe seasonal yield of the ground water basin.

The estimate of safe seasonal ground water yield of the San Joaquin Area is presented in Table 19.

Certain of the items included in the estimate of safe ground water yield are based upon the assumption that the present practice of irrigation by surface water supplies in and adjacent to the San Joaquin Area will continue indefinitely. Under such circumstances, adjacent ground water basins will remain the sources of subsurface inflow to areas of ground water pumping in the San Joaquin Area. Future increases in the amount of surface irrigation in these areas would increase the quantity of subsurface inflow to areas of ground water pumping, thereby increasing the safe ground water yield of the San Joaquin Area. While there is no assurance that surface irrigation practices will continue indefinitely as at present, there is reason to believe that any changes will not be of material significance to the estimated ground water yield for some time into the future.

The foregoing estimate of safe seasonal ground water yield may be considered to represent the net seasonal extraction from the ground water basin that might be maintained without permanent lowering of the water table beyond conditions prevailing in 1952. Having so chosen the determining criteria, estimated safe seasonal ground water yield may be considered to be a property of the ground water basin, not affected by changes in irrigation efficiency, patterns, or practices, providing, however, that water supplies available to the San Joaquin Area continue to be made available as under the assumed conditions.

TABLE 19

ESTIMATED SAFE SEASONAL GROUND WATER YIELD IN UNITS OF SAN JOAQUIN AREA

(In acre-feet)

Item	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit	Totals
Mean water supply under present conditions					
Surface inflow	[a]168,100	779,900	172,700	51,300	1,172,000
Subsurface inflow	—32,300	10,000	35,500	51,400	64,600
Precipitation	91,000	153,000	112,000	112,000	468,000
Subtotals	226,800	942,900	320,200	214,700	1,704,600
Mean surface outflow under present conditions	37,000	[b]752,400	[c]137,500	[d]38,300	965,200
Available to meet total consumptive use requirements	189,800	190,500	182,700	176,400	739,400
Mean consumptive use of water under present conditions					
Precipitation	79,800	121,700	93,300	102,500	397,300
Applied surface water	55,400	8,200	9,300	3,400	76,300
Subtotals	135,200	129,900	102,600	105,900	473,600
SAFE GROUND WATER YIELD	54,600	60,600	80,100	70,500	265,800

[a] Surface inflow to unit increased an estimated 36,000 acre-feet over average for 12-year base period.
[b] Average surface outflow for 12-year base period reduced by 1,400 acre-feet under present conditions, due to increased surface diversions in unit.
[c] Base period average surface outflow reduced by 13,400 acre-feet under present conditions; 12,000 acre-feet new retention in unit due to operation of Hogan Dam, and 1,400 acre-feet due to increased surface diversions from Mormon Slough.
[d] Base period average surface outflow reduced by 3,600 acre-feet under present conditions, due to increased surface diversions in unit.

QUALITY OF WATER

The surface water supplies of the San Joaquin Area are of excellent mineral quality and well suited from that standpoint for irrigation and other beneficial uses. Ground water of good mineral quality occurs generally throughout the area except in certain areas adjacent to the Delta. The principal objectives of the water quality investigation were to evaluate general conditions with respect to quality, and to determine the extent of areas presently affected by saline ground water and the source of such water.

It is desirable to define certain terms commonly used in connection with discussion of quality of water.

Quality of Water—Those characteristics of water affecting its suitability for beneficial uses.

Mineral Analysis—The quantitative determination of inorganic impurities or dissolved mineral constituents in water.

Contamination—Impairment of the quality of water by sewage or industrial waste to a degree which creates a hazard to public health through poisoning or spread of disease.

Degradation—Impairment of the quality of water due to causes other than disposal of sewage and industrial wastes.

Pollution—Impairment of the quality of water by sewage or industrial waste to a degree which does not create a hazard to public health, but which adversely and unreasonably affects such water for beneficial use.

Complete mineral analysis included a determination of three cations, consisting of calcium, magnesium, and sodium; four anions, consisting of bicarbonate, chloride, sulphate, and nitrate; total soluble salts; boron; and computation of percent sodium. Partial analysis included determination of chlorides and total mineral solubles only.

With the exception of boron, the concentrations of cations and anions in a water sample are expressed in this bulletin in terms of "equivalents per million." This was done because ions combine with each other on an equivalent basis, rather than on a basis of weight, and a chemical equivalent unit of measurement provides a better and more convenient expression of concentration. This is especially true when it is desired to compare the composition of water having variable concentration of mineral solubles. In the case of boron, concentrations are expressed on a weight basis of "parts per million" of water. In order to convert equivalents per million to parts per million, the concentration, expressed in equivalents per million, should be multiplied by the equivalent weight of the cation or anion in question. Equivalent weights of the common cations and anions are expressed in the following tabulation:

Cation	*Equivalent weight*	*Anion*	*Equivalent weight*
Calcium	20.0	Bicarbonate	61.0
Magnesium	12.2	Chloride	35.5
Sodium	23.0	Sulphate	48.0
		Nitrate	62.0

Data used to determine the quality of water in the San Joaquin Area included complete mineral analyses of 19 surface water samples, and complete mineral analyses of water samples collected from 44 wells. The data also included partial analyses of water samples collected from 135 wells during the 1949 irrigation season, and from 173 wells during the 1950 irrigation season. Results of partial mineral analyses of water are presented in Appendix F of this bulletin.

In addition to the foregoing, a detailed investigation of the quality of ground water in the vicinity of Stockton has been conducted by the Division of Water Resources under the provisions of Sections 229 and 231 of the Water Code. The results of this investigation are reported in Water Quality Investigation Report No. 7, dated March, 1955. Other data used during the course of the investigation included well water analyses that were obtained from the California

Water Service Company, and surface water analyses obtained by the United States Bureau of Reclamation and published in the Sacramento-San Joaquin Water Supervision Reports of the Division of Water Resources.

Standards of Quality for Water

Investigation and study of the quality of surface and ground waters of the San Joaquin Area, as reported herein, were largely limited to consideration of mineral constituents of the waters, with particular reference to their suitability for irrigation use. However, it may be noted that, within the limits of analyses herein reported, a water which is determined to be suitable for irrigation may also be considered as being either generally suitable for municipal and domestic use, or susceptible to such treatment as will render it suitable for that purpose.

The major criteria which were used as a guide to judgment in determining suitability of water for its irrigation use comprised the following: (1) chloride concentration, (2) total soluble salts, (3) boron concentration, and (4) per cent sodium.

1. The chloride anion is usually the most troublesome element in irrigation waters. It is not considered essential to plant growth, and excessive concentrations will inhibit growth.

2. Total soluble salts furnishes an approximate indication of the over-all mineral quality of water. It may be approximated by multiplying specific electrical conductance ($Ec \times 10^6$ at 25° C.) by 0.7. The presence of excessive amounts of dissolved salts in irrigation water will result in reduced crop yield.

3. Crops are sensitive to boron concentration, but require a small amount (less than 0.1 part per million) for growth. They usually will not tolerate more than 0.5 to 2 parts per million, depending on the crop in question.

4. Per cent sodium reported in the analyses is the proportion of the sodium cation to the sum of all cations, and is obtained by dividing sodium by the sum of calcium, magnesium, and sodium, all expressed in equivalents per million, and multiplying by 100. Water containing a high per cent sodium has an adverse effect upon the physical structure of the soil by dispersing the soil colloids and making the soil "tight," thus retarding movement of water through the soil, retarding the leaching of salts, and making the soil difficult to work.

The following excerpt from a paper by Dr. L. D. Doneen, of the Division of Irrigation of the University of California at Davis, may assist in interpreting water analyses from the standpoint of their suitability for irrigation:

"Because of diverse climatological conditions, crops, and soils in California, it has not been possible to establish rigid limits for all conditions involved. Instead, irrigation waters are divided into three broad classes based upon work done at the University of California, and at the Rubidoux, and Regional Salinity Laboratories of the United States Department of Agriculture.

"Class 1. *Excellent to Good*—Regarded as safe and suitable for most plants under any condition of soil or climate.

"Class 2. *Good to Injurious*—Regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.

"Class 3. *Injurious to Unsatisfactory*—Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.

"Tentative standards for irrigation waters have taken into account four factors or constituents, as listed below.

Factor	*Class 1 excellent to good*	*Class 2 good to injurious*	*Class 3 injurious to unsatisfactory*
Conductance ($Ec \times 10^6$ at 25° C.)	Less than 1,000	1,000-3,000	More than 3,000
Boron, ppm	Less than 0.5	0.5-2.0	More than 2.0
Per cent sodium	Less than 60	60-75	More than 75
Chloride, epm	Less than 5	5-10	More than 10

(End of quotation)

Quality of Surface Water

Analyses of surface water samples collected during the investigational seasons indicate that the waters of all tributary streams in the San Joaquin Area are of excellent mineral quality and well suited for irrigation and other beneficial uses. The waters are characterized by a very low content of chloride, boron, and total mineral solubles. The per cent sodium is generally low, with the exception of a sample taken from the Mokelumne River at the Thornton-Galt Bridge in July, 1949. However, the total mineral solubles in this sample are so low that the moderate per cent sodium has little significance. The occurrence of excellent quality water in the Mokelumne and Calaveras Rivers is also indicated by analyses of water in those streams published in the Sacramento-San Joaquin Water Supervision Reports of the Division of Water Resources dating from 1948. Analyses of drainage water samples collected from Beaver Slough, Hog Slough, and French Camp Slough indicate that these waters are likewise of excellent mineral quality, being very low in total mineral solubles, chloride, boron, and per cent sodium. Analyses of representative surface waters of the San Joaquin Area, sampled in 1948, 1949, and 1950, are presented in Table 20.

Quality of Ground Water

In the course of the present investigation, surveys were made of the mineral quality of ground waters throughout the San Joaquin Area. Complete mineral analyses of water samples indicate that the ground water throughout the San Joaquin Area, like the surface waters, is generally of excellent mineral quality, and well suited for irrigation and other beneficial uses. However, it has been observed for many years that certain deep wells in the immediate vicinity of Stockton have consistently yielded water of a saline content sufficient to limit its beneficial use. For this reason the water sampling program was expanded

TABLE 20

COMPLETE MINERAL ANALYSES OF REPRESENTATIVE SURFACE WATERS OF SAN JOAQUIN AREA

	Date of sample	Conductance, Ec × 10^6 at 25°C.	Boron, in ppm	Mineral constituents, in equivalents per million							Per cent sodium
				Ca	Mg	Na	HCO_3 + CO_3	Cl	SO_4	NO_3	
Tributary streams											
Calaveras River at Jenny Lind	3/21/49	125	0.0	0.62	0.51	0.42	1.10	0.05	0.21	trace	26
Calaveras River at Stockton	3/18/49	123	0.02	0.59	0.53	0.36	1.06	0.08	0.20	trace	24
Mokelumne River at Clements	3/18/49	57	0.0	0.18	0.22	0.36	0.41	0.09	0.13	trace	47
Mokelumne River at Lower Kile Gage	12/ 2/48	39	0.0	0.05	0.21	0.16	0.35	0.04	0.04	0.0	38
Mokelumne River at Thornton-Galt Bridge	3/18/49	102	0.02	0.44	0.52	0.47	0.77	0.11	0.25	trace	33
	7/13/49	40	0.0	0.05	0.12	0.30	0.24	0.03	0.03	0.0	64
Mokelumne River, 2 miles below Benson Ferry	3/25/49	110	0.06	0.47	0.58	0.38	0.91	0.14	0.26	trace	27
Dry Creek at Forni Ranch	3/21/49	185	0.0	0.92	0.91	0.49	1.39	0.13	0.62	trace	21
Littlejohns Creek near Farmington	3/26/50	163	0.36	0.55	1.06	1.24	0.90	0.45	0.45	0.13	43
	3/21/51	168	0.18	0.65	0.67	0.65	1.34	0.11	0.31	0.01	24
Duck Creek near Farmington	3/26/50	151	0.01	0.70	0.96	0.53	1.30	0.25	0.14	0.08	24
Lone Tree Creek near Valley Home	3/26/50	144	0.0	0.76	0.72	0.60	1.10	0.20	0.24	0.07	29
Lone Tree Creek at Austin Road	3/26/50	139	0.0	0.65	0.63	0.46	1.05	0.15	0.30	0.06	26
	3/21/51	587	0.12	2.50	2.14	2.14	5.12	1.21	0.44	0.0	30
Tempo Creek at Jack Tone Road	3/21/51	163	0.10	0.65	0.43	0.51	1.32	0.24	0.08	0.01	25
Drainage waters											
Beaver Slough near Thornton	7/13/49	125	0.0	0.22	0.29	0.47	0.43	0.34	0.08	0.0	48
Hog Slough near Thornton	7/13/49	286	0.0	0.89	0.92	1.10	0.79	1.72	0.19	0.0	38
French Camp Slough at Sharps Lane	3/26/50	156	0.16	0.70	0.68	0.65	1.05	0.30	0.34	0.04	32
	3/21/51	224	0.15	0.85	0.90	0.75	1.79	0.37	0.31	0.02	30

in the vicinity of Stockton for the purpose of locating the source of this saline water.

Areas of Excellent or Good Quality of Ground Water. Except in the vicinity of Stockton, and along the western boundary of the San Joaquin Area, the quality of ground water is excellent or good in the zones tapped by water wells. Comprehensive surveys of the average mineral quality of ground water in the San Joaquin Area were made during the irrigation seasons of 1949 and 1950. These surveys involved the partial analysis of water samples collected from numerous wells to determine total mineral solubles and chlorides. Results of the surveys are summarized in Table 21 and show that the mineral quality of native ground water supplies was generally excellent or good in all units of the San Joaquin Area, except in one well in the Western Mokelumne Unit, several wells in the Stockton area of the Calaveras Unit, and wells in a small area on the western fringe of the Littlejohns Unit, where abnormally high concentrations of chlorides were found.

In addition to the foregoing water samples collected for partial analysis, about 30 samples were collected at random from irrigation wells throughout the San Joaquin Area for complete mineral analysis. The results of these complete analyses are presented in Table 22.

Areas and Sources of Degraded Ground Water. As was mentioned, it has been observed for many years that certain deep wells in the immediate vicinity of Stockton have yielded water of a saline content sufficient to limit its beneficial use. This condi-

TABLE 21

SUMMARY OF PARTIAL MINERAL ANALYSES OF GROUND WATERS IN UNITS OF SAN JOAQUIN AREA, SUMMERS OF 1949 AND 1950

Unit	Number of samples		Chlorides, in equivalents per million				Conductance, Ec × 10^6 at 25° C.	
			Average		Range			
	1949	1950	1949	1950	1949	1950	1949	1950
Western Mokelumne	63	59	1.15	1.12	0.17 to 2.56	0.17 to 2.99	516	525
Eastern Mokelumne	69	41	0.74	0.86	0.28 to 2.25	0.17 to 1.91	332	378
Calaveras								
Area east of Stockton	107	--	0.86	----	0.28 to 2.82	---- ----	357	---
Deep wells in Stockton	25	--	17.10	----	3.09 to 36.62	---- ----	1,670	---
Littlejohns	21	164	0.47	0.84	0.28 to 1.41	0.08 to 7.94	228	309

TABLE 22

COMPLETE MINERAL ANALYSES OF REPRESENTATIVE GROUND WATERS IN UNITS OF SAN JOAQUIN AREA

Unit and well number	Depth of well, in feet	Date of sample	Conductance, Ec × 10^6 at 25° C.	Boron, in ppm	Mineral constituents, in equivalents per million							Per cent sodium
					Ca	Mg	Na	$HCO_3 + CO_3$	Cl	SO_4	NO_3	
Western Mokelumne												
3N/6E-4E2		8/12/52	646	0.0	2.79	2.38	1.92	5.47	0.73	0.65	0.13	26
3N/6E-21Q1	110	8/12/52	974	0.0	2.89	3.70	4.04	7.67	1.75	0.60	0.42	37
Eastern Mokelumne												
3N/7E-9L1		8/13/52	461	0.0	1.95	1.48	1.42	3.51	0.68	0.48	0.16	29
3N/7E-12M1		8/12/52	199	0.0	0.60	0.48	0.90	1.46	0.31	0.06	0.10	44
3N/7E-21M2		8/13/52	214	0.4	0.85	0.38	1.03	1.74	0.28	0.14	0.05	44
3N/7E-25B1		8/13/52	248	0.06	0.85	0.91	0.84	2.11	0.20	0.17	0.02	28
3N/7E-32A1		8/14/52	280	0.01	1.20	0.99	0.84	2.59	0.23	0.10	0.01	26
4N/6E-22L1	130	8/12/52	734	0.0	2.79	2.47	2.47	4.92	1.81	0.65	0.29	31
4N/7E-14B1		8/12/52	333	0.42	1.40	0.99	1.04	2.39	0.73	0.10	0.11	29
4N/7E-20B1	280	8/12/52	206	0.40	0.90	0.53	0.75	1.64	0.28	0.09	0.08	32
Calaveras												
2N/6E-36N1		6/19/48			1.70	1.47	0.91	3.14	0.65	0.17	0.0	22
1N/6E-1M1	242	3/18/52	331		1.35	1.15	0.91	2.39	0.59	0.14	0.27	27
1N/6E-3B1	550	8/15/52	389		0.28	0.16	3.35	2.28	1.52	0.01	0.0	88
1N/6E-12L1	408	8/13/52	316		0.85	0.60	1.74	2.30	0.79	0.05	0.04	55
1N/6E-13M1	408	8/13/52	256		0.55	0.48	1.52	2.26	0.31	0.04	0.0	60
1N/7E-7E1	350	5/ 5/52	270		0.95	0.64	1.22	2.30	0.37	0.11	0.04	43
Littlejohns												
1N/6E-36J1	120	8/30/51	695	1.01	2.74	2.22	2.06	3.74	2.26	0.52	0.35	28
1S/7E-3R1	213	9/ 5/51	305	0.23	1.20	0.90	1.11	2.36	0.56	0.27	0.06	33
1S/7E-23D1		9/ 5/51	236	0.10	0.90	0.68	0.78	1.74	0.39	0.08	0.18	31
1S/7E-29H1		9/ 5/51	360	0.38	1.45	1.15	1.02	2.88	0.37	0.14	0.18	26
1S/9E-17N1	200	9/ 6/51	277	0.13	1.15	0.82	0.87	2.24	0.39	0.08	0.16	29
1S/9E-5M1		6/30/50	180	0.02	0.70	0.79	0.93	1.50	0.40	0.15	0.07	40
1S/9E-18R1		7/10/50	330	0.03	1.25	0.05	0.86	2.15	0.45	0.12	0.17	40
1N/8E-13P1	69	9/ 4/51	445	0.05	1.70	1.73	0.93	2.31	1.02	0.17	0.87	21
1N/8E-26H1		9/ 6/51	236	0.11	0.90	0.91	0.78	1.97	0.31	0.16	0.07	29
1N/8E-32G1		9/ 5/51	405	0.23	1.50	1.48	1.13	2.75	1.02	0.35	0.04	26
1N/8E-34J1	435	7/ 3/50	130	0.09	0.75	0.86	0.73	1.70	0.30	0.18	0.07	31

TABLE 23

COMPLETE MINERAL ANALYSES OF GROUND WATERS IN AREAS OF SALINE DEGRADATION IN SAN JOAQUIN AREA

Unit and well number	Depth of well, in feet	Date of sample	Conductance, Ec × 10^6 at 25° C.	Boron, in ppm	Mineral constituents, in equivalents per million							Per cent sodium
					Ca	Mg	Na	$HCO_3 + CO_3$	Cl	SO_4	NO_3	
Western Mokelumne												
4N/5E-8H1	40	7/11/49	2,780	0.53	7.73	7.31	14.50	3.82	25.34	0.07	0.0	49
4N/5E-8H1	40	8/12/52	3,240	0.48	7.83	9.79	13.44	4.49	26.51	0.03	0.04	43
Calaveras												
1N/6E-4P2	550	8/ 4/51	1,324		1.10	1.07	9.87	3.25	8.74	0.02	0.01	82
1N/6E-10Q1	1,130	7/12/49	2,325	0.80	5.65	4.40	13.59	2.72	21.04	0.01		57
1N/6E-10Q2	970	7/12/49	1,588	0.90	3.12	2.53	10.40	3.04	13.18	0.02		65
1N/6E-10Q4	1,075	7/12/49	3,572	0.35	12.19	8.79	17.05	2.34	34.52	0.03		45
1N/6E-10Q5	1,040	7/12/49	1,380	0.93	2.08	1.80	10.33	3.12	10.98	0.01		73
1N/6E-12F3	1,139	8/12/52	1,260	0.84	3.39	2.22	5.78	3.57	7.95	0.10	0.01	50
1N/6E-15E2	273	7/12/49	2,755	0.33	9.85	5.73	12.68	2.96	25.44	0.01		45
1N/6E-15E2	273	8/12/52	3,300	0.67	9.03	5.43	15.48	2.52	28.06	0.02	0.01	52
1N/6E-16H1		7/12/49	2,713	0.57	8.33	4.94	14.98	2.20	25.36	0.04	0.0	
1N/6E-16H3	275	7/12/49	2,840	0.48	9.62	5.59	14.60	2.10	27.38	0.01		49
1N/6E-17D1	200	7/12/49	2,732	0.62	12.15	7.41	19.70	2.36	36.24	0.03		50
1N/6E-23B1	2,000	9/ 2/52	12,300	0.91	42.66	14.23	66.97	0.72	122.97	0.01		54
Littlejohns												
1S/7E-6J2	90	6/27/50	1,100	0.34	4.80	4.10	2.86	3.00	7.90	0.57	0.38	24
1S/7E-6J2	90	8/30/51	1,310	0.23	5.44	4.19	2.57	2.16	9.53	0.29	0.15	21

tion has also been observed at well 4N/5E-8H1 in the Western Mokelumne Unit, about two miles west of Thornton, and at well 1S/7E-6J2, about one mile east of French Camp. Both of these wells are shallow, being 40 and 90 feet deep, respectively, while the majority of wells in the area of degraded ground water in the vicinity of Stockton are relatively deep, ranging from 200 to 2,000 feet in depth. Results of the analysis of 20 samples from 17 wells yielding degraded water are presented in Table 23.

An inspection of Table 23 reveals a striking similarity in the composition of the degraded waters in the Western Mokelumne and Calaveras Units, their common characteristics being a very high content of sodium and chlorides, and a low content of sulphates. This fact strongly suggests that the degradants have a common source. The probable source is saline water occurring in a deep zone underlying the principal pumping zones in the San Joaquin Area. This zone has long been known to exist. It was found as a result of the drilling of wells for natural gas into the formation and the analysis of water therefrom. Study of well logs indicates that the zone is very deep near the eastern edge of the San Joaquin Area, being about 2,000 feet beneath the ground surface in the Linden area, and that it becomes shallower toward the west, surfacing in the Delta just west of Stockton. Well logs in the Stockton area show this zone to be at a depth of about 1,000 feet. Because of the great depth of the saline water under principal areas of agricultural pumping draft, there has been virtually no saline degradation of irrigation waters in the San Joaquin Area. However, as previously mentioned, several deep wells pumping for municipal and industrial purposes in the City of Stockton have tapped the saline water, and several industrial wells west of Stockton have encountered it at relatively shallow depths.

The problem resulting from saline degradation of ground water has not been serious in the San Joaquin Area up to the present time, there having been little or no diffusion of saline waters into the zones of good water. Proper sealing off of water wells and of abandoned gas wells tapping the zone containing saline water would probably control the problem in the vicinity of Stockton.

Canal Conveying Irrigation Water in Western Mokelumne Unit

CHAPTER III

WATER UTILIZATION AND SUPPLEMENTAL REQUIREMENTS

The nature and extent of water utilization and requirements for supplemental water in the San Joaquin Area, both at the present time and under probable conditions of ultimate development, are considered in this chapter. In connection with the discussion, the following terms are used as defined.

Water Utilization—This term is used in a broad sense to include all employments of water by nature or man, whether consumptive or nonconsumptive, as well as irrecoverable losses of water incidental to such employment, and is synonymous with the term "water use."

Demands for Water—Those factors pertaining to specific rates, times, and places of delivery of water, losses of water, quality of water, etc., imposed by the control, development, and use of the water for beneficial purposes.

Water Requirement—The amount of water needed to provide for all beneficial uses of water and for irrecoverable losses incidental to such uses. As used in this bulletin, the term refers only to consumptive use of water unless otherwise specified.

Supplemental Water Requirement—The water requirement over and above the sum of safe ground water yield and safe surface water yield.

Consumptive Use of Water—This refers to water consumed by vegetative growth in transpiration and building of plant tissue, and to water evaporated from adjacent soil, from water surfaces, and from foliage. It also refers to water similarly consumed and evaporated by urban and nonvegetative types of land use.

Applied Water—The water delivered to a farmer's headgate in the case of irrigation use, or to an individual's meter in the case of urban use, or its equivalent. It does not include direct precipitation.

Ultimate—This refers to conditions after an unspecified but long period of years in the future when land use and water supply development will be at a maximum and essentially stabilized. It is realized that any present forecasts of the nature and extent of such ultimate development, and resultant water utilization, are inherently subject to possible large errors in detail and appreciable error in the aggregate. However, such forecasts, when based upon best available data and present judgment, are of value in establishing long-range objectives for development of water resources. They are so used herein, with full knowledge that their re-evaluation after the experience of a period of years may result in considerable revision.

The present water requirement in the San Joaquin Area was estimated by the application of appropriate unit consumptive use of water factors to the pattern of present land use. The probable ultimate water requirement was similarly estimated, by the use of an ultimate pattern of land use projected from the present pattern on the basis of land classification data, the assumption being made that under ultimate conditions of development all irrigable lands, excepting those devoted to urban and miscellaneous purposes, would be irrigated. As indicated by the foregoing definition, requirements for supplemental water were estimated as the differences between derived values of safe yield and consumptive use of applied water, under both present and ultimate conditions of development.

Certain possible nonconsumptive requirements for water, such as those for hydroelectric power generation, flood control, conservation of fish and wildlife, recreation, etc., will be of varying significance in the design of works to meet supplemental consumptive requirements for water in the San Joaquin Area. In most instances the magnitudes of such nonconsumptive requirements are relatively indeterminate, and dependent upon allocations made in design after consideration of factors of economics. For these reasons, water requirements for hydroelectric power generation, flood control, conservation of fish and wildlife, and recreation are discussed in general terms in this chapter, but not specifically evaluated.

Water utilization is considered and evaluated in this chapter under the general headings "Present Water Supply Development," "Land Use," "Unit Use of Water," "Past and Present Water Requirements," "Probable Ultimate Water Requirement," "Nonconsumptive Water Requirements," and "Demands for Water." Supplemental water requirements are similarly treated under the two general headings "Present Supplemental Requirement," and "Probable Ultimate Supplemental Requirement." Some possible effects of water rights and water law on the estimates of water requirements are discussed under the heading "Legal Considerations."

WATER UTILIZATION

Of the total amount of water presently utilized in the San Joaquin Area, approximately 70 per cent is consumed in the production of irrigated crops, while the remainder is consumed by dry-farmed crops and fallow lands, native vegetation, and miscellaneous culture. It is considered probable that the predominant importance of irrigated agriculture, as related to utilization of water in the area, will continue in the future.

Present Water Supply Development

The water resources of major streams tributary to the San Joaquin Area are generally undeveloped, except in the cases of the Mokelumne and Calaveras Rivers. The waters of the Mokelumne River are subject to heavy draft for irrigation, power, and municipal purposes. At the present time the use of water of the Calaveras River is generally limited to the Calaveras Unit of the San Joaquin Area. Since existing developments on streams tributary to the San Joaquin Area have an important bearing on water supplies available to the area, they are discussed both for the San Joaquin Area and for its tributary watersheds. These existing works are shown on Plates 14 and 16, entitled "Existing Water Conservation Works and Works Considered for Future Development," and "Potential Water Developments," respectively.

San Joaquin Area. Approximately 80 per cent of the acreage under water service in the San Joaquin Area is presently supplied by water pumped from the underlying ground water basin. Irrigated lands utilizing ground water are generally served by individually owned wells and pumps. During 1949 there were approximately 4,400 wells and pumping plants of heavy draft, powered with motors of more than five horsepower. Of this number, approximately 4,300 were used for irrigation. The 100 remaining wells supplied water for urban and industrial purposes. A number of additional wells of light draft supplied limited amounts of water for noncommercial gardens and orchards, and for domestic purposes.

Surface diversions for irrigation in the San Joaquin Area are made from the Mokelumne and Calaveras Rivers, and from Mormon Slough and Littlejohns, Bear, Lone Tree, Duck, and Tempo Creeks. The principal diversion made in the area is from the Mokelumne River, and is made by the Woodbridge Irrigation District which supplied some 16,000 acres of land in the Western Mokelumne Unit in 1951-52. The remainder of surface-supplied lands are served from diversions made by individuals whose lands are adjacent to the surface sources.

Water used for municipal, industrial, and domestic purposes in the San Joaquin Area is obtained almost entirely from wells. The greater part of such use is in the Cities of Stockton and Lodi. The remainder is scattered throughout the area, and is of relatively minor significance.

The City of Stockton is served by the California Water Service Company, which pumps water from wells into storage tanks, from which it is delivered to consumers by gravity. Water services are metered. The quantity of water pumped for use in Stockton during the calendar year 1950 was 4,920 million gallons, or 15,100 acre-feet. With an approximate population of 70,800 in 1950, the daily production averaged about 190 gallons per capita.

Lodi is served by the Lodi Municipal Water Works which charges for water on a flat-rate basis. It was estimated that the quantity of water pumped for use in Lodi during the calendar year 1949 was about 2,580 million gallons, or 7,900 acre-feet. With an approximate population of 13,800 in 1950, the daily production averaged about 510 gallons per capita.

In addition to the foregoing figures regarding ground water pumped under the municipal systems of Stockton and Lodi, it was estimated that approximately 12,000 acre-feet was pumped and used by industries operating their own wells within the cities. Lockeford, Clements, Thornton, Victor, and Linden have community water systems that distribute water from storage tanks supplied by wells. The estimated amount of water pumped in Lockeford during the calendar year 1950 was approximately 150 acre-feet. Assuming that the per capita water production in remaining small towns and communities in the San Joaquin Area is about 200 gallons per day, it was estimated, on the basis of 1950 population estimates, that total annual pumpage from ground water for these communities was about 1,400 acre-feet.

The respective areas within the several units of the San Joaquin Area served by ground water and surface water are shown in Table 24. The data presented for the two seasons, 1948-49 and 1951-52, resulted from field surveys during the current investigation, whereas the averages reported for the base period were estimated from data obtained by prior surveys made by various agencies.

Table 25 lists the principal water service agencies, together with notations on their sources of water supply, and locations of service areas within the San Joaquin Area. Areas included within the boundaries of these agencies are shown on Plate 2.

There are no significant diversions of the waters of Dry Creek in the San Joaquin Area.

As has been stated, the principal diversion of water from the Mokelumne River in the San Joaquin Area is made by the Woodbridge Irrigation District. The diversion point is in Sections 34 and 35, Township 4

TABLE 24

GROUND AND SURFACE WATER SERVICE AREAS IN UNITS OF SAN JOAQUIN AREA

(In acres)

Unit	Ground water		Surface water	
	1948-49	1951-52	1948-49	1951-52
Western Mokelumne	21,300	25,340	24,050	25,480
Eastern Mokelumne	43,030	47,450	4,900	5,070
Calaveras	39,000	37,390	4,400	7,090
Littlejohns	28,850	41,110	540	1,000
TOTALS	132,180	151,290	33,890	38,640
Estimated averages for 12-year base period, 1939-40 through 1950-51	106,500		31,300	

TABLE 25

PRINCIPAL WATER SERVICE AGENCIES IN SAN JOAQUIN AREA

Agency	Source of supply	Unit in which service area is located
California Water Service Company	Ground water	Calaveras
City of Lodi	Ground water	Eastern Mokelumne
Linden Irrigation District (inactive)	Calaveras River and private wells	Calaveras
Mokelumne River Irrigation District (inactive)	Mokelumne River and private wells	Eastern Mokelumne
North San Joaquin Water Conservation District	Mokelumne River and private wells	Eastern Mokelumne
Stockton and East San Joaquin Water Conservation District	Calaveras River and private wells	Calaveras
Woodbridge Irrigation District	Mokelumne River and Delta	Western Mokelumne, Eastern Mokelumne, Calaveras
Woodbridge Water Users Association	Mokelumne River and Delta	Western Mokelumne
Oak Park Court Water Company	Ground water	Calaveras
Stockton Land Association	Ground water	Calaveras
Swain Oaks Manor Water Company	Ground water	Western Mokelumne
Victor Water Company Incorporated	Ground water	Eastern Mokelumne
West Lane Heights Water Company	Ground water	Calaveras
Silver Gardens Mutual Water Company	Ground water	Calaveras
Thornton Water Company	Ground water	Western Mokelumne
San Joaquin County Waterworks District No. 1	Ground water	Eastern Mokelumne
San Joaquin County Waterworks District No. 2	Ground water	Eastern Mokelumne
Colonial Heights Maintenance District	Ground water	Western Mokelumne
Lincoln Village Maintenance District	Ground water	Western Mokelumne

North, Range 6 East, M. D. B. & M. The diversion weir is of the buttress type and is provided with flashboards. The height of the dam is 31.5 feet above the stream bed elevation of 16.5 feet, and the dam has a crest length of about 240 feet. The diverted water passes through headgates on the left bank of the weir, and is distributed to irrigators by means of a canal system having a total length of about 70 miles. The canal system of the district extends from Woodbridge south to the Calaveras River. The district also pumps water from Beaver Slough to augment its water supply in the vicinity of Thornton. The pump diversion is located near the northwest corner of Section 14, Township 4 North, Range 5 East, M. D. B. & M. The pump installation comprises two 25-horsepower, electrically driven pumps and motors, each having a pumping capacity of 6,000 gallons per minute. Lands served by the Woodbridge Irrigation District include lands of the Woodbridge Water Users Association which are situated outside the district. Lands of the Woodbridge Irrigation District total about 14,200 acres, while those of the Woodbridge Water Users Association capable of service by the district are reported to total about 21,200 acres. During the 1951-52 irrigation season, 124,900 acre-feet of water were diverted at the Woodbridge Diversion Dam, and the water was applied on 16,218 acres of irrigated land. Of this total, 5,908 acres were situated outside the Woodbridge Irrigation District. The measured and estimated surface outflow of water to the Delta from the Woodbridge Irrigation District canal system in 1951-52 was 22.7 per cent of the total diversion made at Woodbridge Dam during that season. Table 26 shows the total seasonal diversion of Mokelumne River water at Woodbridge Dam for the period from 1926-27 to 1951-52. The measurement of the diverted flow is made by means of a differential water stage recorder and gate opening recorder, both of which are maintained and operated by the United States Geological Survey.

There were 71 irrigation pumping plants diverting water from the Mokelumne River in 1951-52 between

TABLE 26

RECORDED SEASONAL DIVERSION OF MOKELUMNE RIVER WATER BY WOODBRIDGE IRRIGATION DISTRICT

(In acre-feet)

Season	Diversion	Season	Diversion
1926-27	40,600	1939-40	91,630
27-28	35,700	40-41	93,150
28-29	51,100	41-42	89,860
29-30	63,900	42-43	103,500
		43-44	119,800
1930-31	68,000		
31-32	71,600	1944-45	113,600
32-33	92,900	45-46	121,600
33-34	93,900	46-47	118,200
34-35	80,220	47-48	111,200
		48-49	132,200
1935-36	81,230		
36-37	92,230	1949-50	147,700
37-38	80,930	50-51	118,000
38-39	93,880	51-52	124,400

the eastern boundary of the San Joaquin Area and the eastern edge of the Delta. Lands served by these pumps are partly riparian. The total acreage served from the pumped diversions in 1951-52 was estimated to have been about 4,900 acres, and the total water pumped was estimated to have been about 10,800 acre-feet.

Seven irrigation pumping plants located on Bear Creek served about 460 acres in 1951-52, the source of water supply being return flow from adjacent irrigated lands. This acreage was also served supplemental water obtained directly from the ground water basin by wells.

The presently inactive Linden Irrigation District in the Calaveras Unit was formed in 1929 for the purpose of providing additional ground water replenishment in the upper portion of the Calaveras Unit. In 1933, in cooperation with the Federal Government, the district deepened and widened the Calaveras River for a distance of 8,400 feet west of Bellota, and constructed a headgate in the Calaveras River at Bellota and three check dams downstream therefrom. During the four-year period from 1934 to 1938, an estimated 77,000 acre-feet of water were diverted through the headgate at Bellota, of which about 12,000 acre-feet were imported from the Stanislaus River watershed. Subsequently, the district became inactive.

In 1948, the Stockton and East San Joaquin Water Conservation District was organized "to preserve and secure the replenishment of the underground waters in the Stockton and East San Joaquin Area." Late in that year steps were taken to retain a portion of the Calaveras River waters which waste to the Sacramento-San Joaquin Delta even in moderately dry years. A weir was constructed at the head of Mormon Slough to divert Calaveras River water otherwise wasting to Mormon Slough back into the Calaveras River. The diverted water flowed to existing percolation ponds constructed in the river by the Linden Irrigation District. Also, an agreement was entered into between the City of Stockton and the Stockton and East San Joaquin Water Conservation District, providing for the utilization of storage space in Hogan Reservoir by the district for such conservation purposes as would not impair its utility for flood control. During the period from 1948-49 through 1951-52, a total of approximately 60,000 acre-feet of Calaveras River waters were retained by these two measures, over and above that amount which normally would have been retained.

There was a total of 66 irrigation pumping plants in operation in 1951-52 on Mormon Slough, the Stockton Diverting Canal, the Calaveras River, and North Slough. Three gravity diversions were made from the Calaveras River below the headgate of the Stockton and East San Joaquin Water Conservation District in that year. The total area served in 1951-52 by these pumps and gravity diversions was estimated to have been 6,200 acres, and the area was supplied a total of 11,600 acre-feet of water.

There were 10 irrigation pumping plants in operation in 1951-52 on Duck, Littlejohns, Tempo, and Lone Tree Creeks. One direct gravity diversion of water was made from Littlejohns Creek, and seven were made from Lone Tree Creek. The total area served by these irrigation pumping plants and direct gravity diversions was approximately 1,000 acres, and the amount of irrigation water served was estimated to have been about 5,000 acre-feet. The source of the diverted water supply was mostly return flow from adjacent irrigated lands. This acreage also received supplemental water from pumped ground water.

Tributary Watersheds. Principal streams tributary to the San Joaquin Area which have an important bearing on water supplies available to the area are Dry Creek, Mokelumne River, Calaveras River, and Littlejohns Creek.

At the present time only a small portion of the water resources of the Dry Creek watershed is being put to beneficial use. The only significant water supply development in the watershed is that of the Preston School of Industry near Ione in western Amador County. This institution diverts water in Section 1, Township 6 North, Range 10 East, M. D. B. & M., from Sutter Creek, a tributary of Dry Creek, for irrigation, domestic, and power uses on the school property. The water supply system of the institution includes four small reservoirs with a total gross storage capacity of about 770 acre-feet. Applications to appropriate water for the institution call for 817 acre-feet of storage per annum, in addition to 7 second-feet direct diversion during the irrigation season and 4.5 second-feet direct diversion during the nonirrigation season. Other diversions of water in the Dry Creek watershed are so small as to be considered negligible.

The principal users of water from the Mokelumne River watershed are the Pacific Gas and Electric Company, the East Bay Municipal Utility District, and the Woodbridge Irrigation District. At present only nominal quantities of applied water are consumed within the watershed and outside of the San Joaquin Area. An average of about 8,000 acre-feet of water seasonally has been diverted from the North Fork of the Mokelumne River to Amador County, and about 6,000 acre-feet are diverted from the South and Middle Forks of the Mokelumne River to Calaveras County.

The North Fork of the Mokelumne River has been extensively developed by the Pacific Gas and Electric Company for the generation of electrical energy. In the upper reaches of the North Fork water is impounded in Twin Lakes, Upper and Lower Blue Lakes, Meadow Lake, and Bear River and Salt Springs Reservoirs. The aggregate storage capacity of these reservoirs is about 165,000 acre-feet, of which Salt Springs Reservoir has a capacity of about 140,000 acre-feet. Water is conveyed from Salt Springs Reservoir through the Salt Springs, Tiger Creek, and West Point Power Houses, all located on the North Fork, and through Electra Power House located on the main stem of the Mokelumne River. These power houses have a combined installed power capacity of about 185,000 kilowatts, and utilize a combined gross static head of over 3,000 feet. The conveyance of water between the Salt Springs and Tiger Creek Power Houses is by means of a concrete bench flume. Water from Bear River and from several small tributaries of the North Fork of the Mokelumne River is intercepted by the flume enroute. Water is conveyed through tunnels between the Tiger Creek and West Point Power Houses, and thence to the Electra Power House. The Amador Canal diverts water for domestic and irrigation uses in Amador County from Tabeaud Reservoir which acts as the forebay to the Electra Power House.

The recorded seasonal diversions of water into the Amador Canal, as measured by the East Bay Municipal Utility District for the period from 1925-26 through 1951-52, are presented in Table 27. The Pacific Gas and Electric Company has recently completed the Lower Bear River Reservoir on Bear River for hydroelectric power purposes. This reservoir has a storage capacity of 50,000 acre-feet. Except for the diversions into the Amador Canal, all water utilized by the Pacific Gas and Electric Company in the foregoing system is returned to the Mokelumne River.

TABLE 27

RECORDED SEASONAL DIVERSIONS INTO AMADOR CANAL

(In acre-feet)

Season	Diversion	Season	Diversion
1925-26	8,100	1939-40	8,590
26-27	8,350	40-41	8,020
27-28	8,130	41-42	7,910
28-29	7,940	42-43	6,830
		43-44	6,840
1929-30	8,000		
30-31	8,360	1944-45	7,300
31-32	7,590	45-46	7,560
32-33	8,730	46-47	7,490
33-34	10,040	47-48	6,700
		48-49	6,430
1934-35	9,080		
35-36	10,500	1949-50	6,970
36-37	10,700	50-51	6,220
37-38	8,690	51-52	5,600
38-39	9,550		

Water rights pertaining to the Amador Canal, based upon use prior to the date of the Water Commission Act, agreements, and court decision, provide for an annual diversion of 15,000 acre-feet at a rate not to exceed 30 second-feet.

The Mokelumne River is the principal source of water supply for the metropolitan area along the east shore of San Francisco Bay. This area is served by the East Bay Municipal Utility District. Included within the boundaries of the district are the Cities of Oakland, Berkeley, Alameda, Richmond, Albany, San Leandro, El Cerrito, Piedmont, Emeryville, San Pablo, Walnut Creek, Pinole, and Hercules, as well as numerous smaller communities. Pardee Dam and Reservoir, constructed by the district in 1929, has a storage capacity of 210,000 acre-feet, and constitutes the largest existing development for conservation of water on the Mokelumne River. Pardee Dam is located in Section 26, Township 5 North, Range 10 East, M. D. B. & M., at a point where the stream bed elevation is 225 feet. The dam is of the arched gravity type, 345 feet in height from stream bed to crest. A hydroelectric power plant is located at the downstream toe of the dam.

The East Bay Municipal Utility District holds a permit to appropriate water, providing for a continuous diversion of 310 second-feet, or 200 million gallons daily, of the natural flow of the Mokelumne River, augmented by draft on storage. This diversion is made through an aqueduct extending from Pardee Reservoir to the San Francisco Bay Area. The location of the aqueduct is shown on Plate 14. The aqueduct used to convey diverted water to the Bay area was designed to include three parallel pipe lines. The first line was completed in 1929 and the second in 1949. With the aid of two booster pumping plants en route, the combined capacity of the first and second lines will be sufficient to convey the full amount of the claimed appropriation, or 310 second-feet, to terminal reservoirs located in the Bay area. Recorded seasonal diversions from Pardee Reservoir by the East Bay Municipal Utility District for the period from 1928-29 through 1951-52 are given in Table 28.

TABLE 28

RECORDED SEASONAL DIVERSIONS FROM PARDEE RESERVOIR TO EAST SAN FRANCISCO BAY AREA

(In acre-feet)

Season	Diversion	Season	Diversion
1928-29	16,590	1939-40	40,690
		40-41	45,070
1929-30	46,460	41-42	45,090
30-31	58,410	42-43	47,830
31-32	50,280	43-44	73,640
32-33	41,420		
33-34	23,320	1944-45	75,350
		45-46	100,440
1934-35	40,270	46-47	107,460
35-36	44,490	47-48	109,040
36-37	44,030	48-49	127,700
37-38	43,520		
38-39	39,910	1949-50	114,140
		50-51	93,770
		51-52	102,830

The only significant development of water of the Mokelumne River for use in Calaveras County is that of the Calaveras Public Utility District. This district was organized in 1934, and furnishes water chiefly to domestic and industrial users in and near the towns of Mokelumne Hill and San Andreas. The water rights claimed by the district consist of old mining rights initiated prior to the formulation of the Water Commission Act, and subsequently acquired by the district. The Calaveras Public Utility District presently operates under an agreement with the East Bay Municipal Utility District, the terms of which specify that a continuous flow of water in the amount of 500 miner's inches, or 12.5 second-feet, may be diverted, or a total of about 9,000 acre-feet per season, if available, and that the maximum rate of diversion may be 600 miner's inches, or 15 second-feet.

The diversion by the Calaveras Public Utility District is made at a small dam, located on the South Fork of the Mokelumne River about two miles above its junction with the Middle Fork, at the head of the Mokelumne Hill Ditch. The records of seasonal diversions for the period from 1929-30 through 1951-52 are shown in Table 29, and were obtained by the East Bay Municipal Utility District.

TABLE 29

RECORDED SEASONAL DIVERSION FROM SOUTH FORK OF MOKELUMNE RIVER BY CALAVERAS PUBLIC UTILITY DISTRICT

(In acre-feet)

Season	Diversion	Season	Diversion
1929-30	7,270	1941-42	7,820
30-31	4,770	42-43	7,860
31-32	5,250	43-44	6,250
32-33	6,270		
33-34	4,440	1944-45	6,110
		45-46	5,680
1934-35	4,120	46-47	5,260
35-36	4,530	47-48	5,620
36-37	7,700	48-49	5,160
37-38	7,540		
38-39	7,530	1949-50	5,740
		50-51	5,810
1939-40	7,460	51-52	6,320
40-41	7,960		

The water that is available at the headgate of the Mokelumne Hill Ditch is the natural flow of the South Fork of the Mokelumne River, augmented by diversions from its Middle Fork. The water from the Middle Fork of the Mokelumne River is diverted from that stream about 1½ miles below a reservoir of 1,700 acre-foot storage capacity constructed by the Calaveras Public Utility District in 1940. The diverted water is conveyed through the Middle Fork Ditch to the Licking Fork, a distance of about two miles. It is then released to the Licking Fork, a tributary of the South Fork, near Railroad Flat at a point about four miles above the headgate of the Mokelumne Hill Ditch.

The town of West Point in Calaveras County obtains its water supply through a small canal which conveys water diverted from Bear and Forest Creeks, which are tributaries of the Middle Fork of the Mokelumne River. The canal is in a poor state of repair, and deliveries to its terminal reservoir are inadequate to satisfy the present water requirements of the community.

Except for its use in the Calaveras Unit of the San Joaquin Area, little water of the Calaveras River is presently utilized within the watershed. In the past there were numerous diversion structures and ditch systems which made possible the conveyance of water from the various tributaries of the Calaveras River to different areas for mining purposes. Although a few of these old mining ditches are still used to serve irrigation water to small local areas, the majority have been abandoned for many years. Two small reservoirs on the headwaters of the Calaveras River provide a minor supply of water for uses in Calaveras County. One of these, Bingham Reservoir, is located on the North Fork of the Calaveras River about two miles southeast of Railroad Flat. The reservoir has a storage capacity of 775 acre-feet, and is operated by the Calaveras Public Utility District. The other, Emery Reservoir, is located on the headwaters of McKinneys Creek, a tributary of Calaveritas Creek, about 10 miles east of the town of San Andreas. This reservoir stores about 400 acre-feet of water which is used for irrigation purposes in the immediate area. Most of the water presently utilized in the Calaveras River watershed outside of the San Joaquin Area is imported from the Mokelumne River through facilities of the Calaveras Public Utility District, as previously discussed.

The only major development on the Calaveras River is Hogan Dam and Reservoir, which is owned and operated by the City of Stockton. Hogan Dam was built by the city in 1930, and is located in a narrow canyon just below the confluence of Bear Creek and Calaveras River, in Section 31, Township 4 North, Range 11 East, M. D. B. & M., about three miles southerly from the town of Valley Springs. Hogan Dam was built for the purpose of controlling floods on the Calaveras River to afford protection to Stockton and adjacent areas. The structure is a concrete variable-radius arch dam with concrete gravity abutments. The maximum height of the dam in the center of the spillway is 107.5 feet above the stream bed elevation of 529 feet. The capacity of the spillway is 76,000 second-feet. Nine flood control outlets are provided through the dam. As previously discussed, the Stockton and East San Joaquin Water Conservation District, through an agreement with the City of Stockton, has arranged to utilize a part of the storage space in Hogan Reservoir for water conservation, by installing and operating gates on the flood control outlets. Such utilization of storage space is made after the danger of floods has passed.

Principal water resources developments on Littlejohns Creek comprise the Salt Springs Valley Dam and Reservoir on Rock Creek, a tributary of Littlejohns Creek; Woodward Dam and Reservoir on Simmons Creek, a tributary of Littlejohns Creek; and Farmington Dam and Reservoir on Littlejohns Creek.

Salt Springs Valley Dam is located on Rock Creek in Section 16, Township 2 North, Range 11 East, M. D. B. & M., at a point where the stream bed elevation is 1,132 feet. The dam is composed of rock and earthfill, and was constructed about 1862. In 1880 the dam was enlarged to its present height and size. It has a height of 42 feet from stream bed to spillway lip, and a crest length of 2,000 feet. Storage capacity of Salt Springs Valley Reservoir is about 10,900 acre-feet. The dam and reservoir is owned by the Rock Creek Water District, the service area of which is located about six miles downstream from the dam. During the period from 1936 through 1938, water from Salt Springs Reservoir was conveyed through a ditch to South Gulch, a tributary of the Calaveras River. Then the water flowed down the natural channel to the Calaveras River, from which it was diverted and applied to lands in the vicinity of Linden located in the San Joaquin Area. The area presently served from the reservoir comprises the irrigated lands of the Rock Creek Water District, totaling some 700 acres.

Woodward Dam and Reservoir is owned by the South San Joaquin Irrigation District. The earthfill dam is located in Section 9, Township 1 South, Range 10 East, M. D. B. & M., on Simmons Creek, a tributary of Littlejohns Creek. Height of the dam from the stream bed elevation of 150 feet to the spillway lip is 60 feet, and its crest is 3,100 feet in length. Storage capacity of the reservoir is 36,000 acre-feet. Water stored in Woodward Reservoir is obtained from the Stanislaus River by diversion of its waters at Goodwin Dam, located about four miles upstream from Knights Ferry on the Stanislaus River. Water released from Woodward Reservoir is conveyed to lands in the South San Joaquin Irrigation District, located south of the Littlejohns Unit. The Oakdale Irrigation District, jointly with the South San Joaquin Irrigation District, owns Goodwin Dam and a portion of the main diversion canal. In serving lands north of the Stanislaus River, the Oakdale Irrigation District in part makes use of the channel of Littlejohns Creek. Operations of the Oakdale and South San Joaquin Irrigation Districts are of significance in study of the water resources of the San Joaquin Area. This is true because a portion of the spill from the water systems of the two districts, conveyance losses, Woodward Reservoir percolation losses, and unconsumed applied irrigation water, are in part the sources of water supply to the Littlejohns Unit.

Farmington Dam and Reservoir is owned and operated by the Federal Government, and was constructed to furnish flood protection to the City of Stockton and the surrounding area, as well as to lands and improvements along Littlejohns Creek. Farmington Dam is located on Littlejohns Creek, in Section 25, Township 1 North, Range 9 East, M. D. B. & M., at a point where the stream bed elevation is 116 feet. The dam is an earthfill structure, 40.5 feet in height from stream bed to spillway lip, and with a crest length of 7,800 feet. Storage capacity of the reservoir is 52,000 acre-feet, and its spillway capacity is 12,600 second-feet. Since the reservoir is operated solely in the interest of flood control, little or no conservation of the waters of Littlejohns Creek results.

Appropriation of Water. Since the effective date of the Water Commission Act on December 19, 1914, and up to November 1, 1953, some 340 applications to appropriate water of streams of the San Joaquin Area have been filed with the Division of Water Resources or its predecessors. These applications are listed in Appendix G, together with pertinent information on the proposed diversions and uses of water and present status of the applications.

The applications listed in Appendix G should not be construed as comprising a complete or even partial statement of water rights in the San Joaquin Area. They do not include appropriative rights initiated prior to December 19, 1914, riparian rights, correlative rights of overlying owners in ground water basins, nor prescriptive rights which may have been established on either surface streams or ground water basins, none of which are of record with the Division of Water Resources.

In general, water rights may be firmly established only by court decree. A discussion of the legal aspects of water rights in the San Joaquin Area is contained in a later section of this chapter.

Dams Under State Supervision. The Department of Public Works, acting through the agency of the State Engineer, supervises the construction, enlargement, alteration, repair, maintenance, operation, and removal of dams, for the protection of life and property within California. All dams in the State, excepting those under federal jurisdiction, are under the jurisdiction of the department. "Dam" means any artificial barrier, together with appurtenant works, if any, across a stream, watercourse, or natural drainage area, which does or may impound or divert water, and which either (a) is or will be 25 or more feet in height from natural stream bed to crest of spillway, or (b) has or will have an impounding capacity of 50 or more acre-feet. Any such barrier, which is or will be not in excess of six feet in height, regardless of storage capacity, or which has or will have a storage capacity not in excess of 15 acre-feet, regardless of height, is not considered a dam. Approximately 40 dams in the San Joaquin Area are presently under state supervision. Pertinent data relating to these dams are included in Appendix II.

Land Use

As a first step in estimating the water requirements in the San Joaquin Area, determinations were made of the nature and extent of land use prevailing during the base period and investigational seasons. Similarly, the probable nature and extent of ultimate land use, as related to the water requirement, was forecast on the basis of land classification survey data which segregated lands of the area in accordance with their suitability for irrigated agriculture.

Past and Present Patterns of Land Use. Aerial photos taken of the San Joaquin Area by the United States Department of Agriculture in 1937 provided the necessary information to determine land use with regard to acreages and general types of irrigated crops at that time. In 1946 the United States Bureau of Reclamation made a complete crop survey of the area. A comprehensive land use survey was made during the seasons of 1948-49 and 1951-52 as a part of the current investigation. Additional data on land use were obtained in the Littlejohns Unit in 1949-50 and 1950-51, from supplemental surveys made in order to determine changes in land use since the preceding season.

Data available from the foregoing surveys were sufficient to estimate the average land use pattern in the San Joaquin Area during the 12-year base period. For purposes of this report, the pattern existing during 1951-52 was considered to represent "present" conditions of land use and development in the area, and is so referred to in subsequent discussion. Summaries of results of the land use survey of 1951-52, and of the estimated average pattern for the base period, are presented in Table 30. Lands irrigated in the San Joaquin Area during the 1951-52 season are shown on Plate 15, entitled "Irrigated and Irrigable Lands, 1951-52." Summaries of the comprehensive land use survey made during the 1948-49 season, and of the supplemental surveys made in the Littlejohns Unit during the 1949-50 and 1950-51 seasons, are included in Appendix I.

The most significant recent trend in irrigated agriculture in the San Joaquin Area is toward increased plantings of permanent pasture. Substantial increases in the acreages of rice and alfalfa are also indicated. The data presented in Table 30 show that the area of permanent pasture increased from an estimated average of some 36,000 acres during the base period to approximately 67,000 acres in 1951-52, an increase of nearly 31,000 acres. At the same time, rice increased from some 3,500 to 11,500 acres. Although the increase in rice acreage does not compare in magnitude with the increase in acreage of permanent pasture, it is interesting to note that the percentage increase from the base period average to the present is more than threefold. In view of the fact that this increase has largely occurred during the past few seasons, the trend may be significant. Vineyard, which had long been the largest irrigated crop in the area on an acreage basis, showed a decrease of more than 1,000 acres in 1951-52 from the base period average, as did deciduous orchard, which also had always been one of the leading crops in the area. The over-all increases in irrigated agriculture in the San Joaquin Area were reflected largely by corresponding decreases in the acreage of dry-farmed and fallow lands. Table 30 also shows that there was substantial increase in urban development in 1951-52 over the base period average, especially around the City of Stockton. There was a moderate increase in farmstead development during the same period, but no significant changes in remaining types of land use in the San Joaquin Area.

Probable Ultimate Pattern of Land Use. Classification of lands of the San Joaquin Area with respect to their suitability for irrigated agriculture was largely accomplished by other agencies prior to the San Joaquin County Investigation. Many valuable data on land classification were available from and furnished by the United States Bureau of Reclamation. The available data were supplemented and checked as required in the course of field surveys conducted as a part of the investigation.

The land classification was based on standards involving physical factors and known inherent conditions of soils, topography, and drainage. The conditions relative to the soils that largely determine their suitability for irrigation are depth of soil, texture, and structure. These physical factors to a large extent determine the moisture-holding capacity, the root zone area, the ease of irrigation and cultivation, and the available nutrient capacity of the soil. Topographic conditions considered were the degree of slope and undulations. These affect the ease of irrigation and the type of irrigation practice required to provide water at a proper rate to cropped land. A proper rate of irrigation application will permit the soil to absorb and hold moisture without erosion or excessive losses through runoff or percolation. Drainage is highly important and is closely associated with problems of salinity and alkalinity, and waterlogging of lands. It was assumed that under conditions of ultimate development all lands suitable for drainage reclamation will be reclaimed.

Economic factors relating to the development, production, or marketing of adaptable crops were not considered in making the land classification, nor were costs of clearing, leveling, or other operations re-

TABLE 30

PAST AND PRESENT PATTERNS OF LAND USE IN UNITS OF SAN JOAQUIN AREA

(In acres)

Class and type of land use	Western Mokelumne Unit		Eastern Mokelumne Unit		Calaveras Unit		Littlejohns Unit		Totals	
	Estimated base period average, 1939-40 through 1950-51	Present, 1951-52	Estimated base period average, 1939-40 through 1950-51	Present, 1951-52	Estimated base period average, 1939-40 through 1950-51	Present, 1951-52	Estimated base period average, 1939-40 through 1950-51	Present, 1951-52	Estimated base period average, 1939-40 through 1950-51	Present, 1951-52
Irrigated lands										
Permanent pasture	15,500	19,460	7,730	14,230	3,730	6,460	8,920	27,260	35,880	67,410
Vineyard	13,300	13,300	27,530	26,610	270	90	310	230	41,410	40,230
Deciduous orchard	1,940	1,590	3,870	3,400	17,900	17,860	2,170	1,910	25,880	24,760
Alfalfa	4,660	4,550	1,190	1,800	980	3,670	680	3,000	7,510	13,020
Beans	470	740	1,120	1,930	3,870	9,030	300	390	5,760	12,090
Tomatoes	3,990	3,270	30	2,310	5,030	5,100	480	760	9,530	11,440
Rice	420	2,390	----	290	900	790	2,140	8,000	3,460	11,470
Truck	900	2,520	430	1,350	1,620	1,010	500	250	3,450	5,130
Asparagus	2,870	2,600	----	40	90	----	----	----	2,960	2,640
Sugar beets	510	400	10	560	570	470	200	210	1,290	1,640
Miscellaneous	----	----	440	----	280	----	----	100	720	100
Subtotals	44,560	50,820	42,350	52,520	35,240	44,480	15,700	42,110	137,850	189,930
Dry-farmed and fallow lands	23,970	16,620	57,480	47,130	38,130	24,210	75,580	47,910	195,160	135,870
Native vegetation	740	670	3,500	2,890	260	260	280	280	4,780	4,100
Miscellaneous										
Urban	610	1,590	1,650	2,150	8,800	12,220	300	1,150	11,360	17,110
Farmsteads	1,000	1,080	1,650	1,710	1,040	1,530	450	660	4,140	4,980
Roads	1,020	1,080	1,650	1,710	850	1,530	500	700	4,020	5,020
Highways and railroads	1,020	1,060	1,470	1,490	600	690	1,550	1,550	4,640	4,790
Water surface	350	350	740	740	510	510	100	100	1,700	1,700
Waste lands	80	80	310	460	540	540	----	----	930	1,080
Swamps	120	120	----	----	----	----	----	----	120	120
Subtotals	4,200	5,360	7,470	8,260	12,340	17,020	2,900	4,160	26,910	34,800
TOTALS	73,470	73,470	110,800	110,800	85,970	85,970	94,460	94,460	364,700	364,700

quired to prepare lands for cultivation. The classification was predicated on the ultimate potential of the land, without regard to availability of water or present land utilization. On the basis of the foregoing standards, agricultural lands of the San Joaquin Area were segregated into the following five classes:

Class 1. This class comprises lands that are highly desirable in every respect for continuous irrigated agricultural use, and capable of producing all climatically adapted crops. The soils are deep, with good surface and subsoil drainage, of medium to fairly fine texture, and of good water-holding capacity. The soil structure is such as to permit easy penetration of roots, air, and water, and the land surface is smooth and gently sloping.

Class 2. This class comprises lands that are generally limited to climatically adapted medium-rooted crops, due to the restrictive features of the soil depth, and to a minor extent, of topography or drainage. They are well suited for development under irrigation.

Class 3. This class comprises lands that are generally limited in their use to climatically adapted shallow-rooted crops, owing to deficiencies in soil depth, moisture-holding capacity, topography, or to drainage characteristics. This class of lands is suitable for development under irrigation, but because of shallow soil depths, greater care and skill are required in the application of water.

Class 4. This class comprises lands that fail to meet the standards of Classes 1, 2, and 3, as to topography, drainage, and depth of soil. These lands are generally suitable only for permanent pasture or similar crops.

Class 5. This class comprises all lands that do not meet the minimum requirements of suitability for irrigation use.

In addition to agricultural lands, 17,110 acres in the San Joaquin Area were classified as urban. Results of the land classification of the San Joaquin Area, summarized by units, are presented in Table 31.

By use of the land classification data, a probable ultimate pattern of land use for the San Joaquin Area was forecast. The general assumption was made that under an increasing pressure of demand for


(Courtesy of Lodi Chamber of Commerce)
Irrigated and Irrigable Lands Near Confluence of Dry Creek and Mokelumne River

TABLE 31

CLASSIFICATION OF LANDS IN UNITS OF SAN JOAQUIN AREA

(In acres)

Unit	Land classes 1	2	3	4	6	Urban	Totals
Western Mokelumne	31,600	22,510	17,550	------	220	1,590	73,470
Eastern Mokelumne	32,800	22,920	27,650	20,490	4,790	2,150	110,800
Calaveras	35,990	26,120	6,950	3,750	940	12,220	85,970
Littlejohns	990	26,730	57,960	6,390	1,240	1,150	94,460
TOTALS	101,380	98,280	110,110	30,630	7,190	17,110	364,700

agricultural products all irrigable presently dry lands would eventually be provided with irrigation service. Provision was also made for probable increase in lands devoted to farmsteads, roads, urban, and other miscellaneous purposes under conditions of probable ultimate development.

The estimated ultimate pattern of land use of the San Joaquin Area, summarized by general classes of such use and by units of the area, is presented in Table 32. Irrigable lands, as determined by the land classification survey data, and as indicated by the probable ultimate pattern of land use, are shown on Plate 15.

TABLE 32

PROBABLE ULTIMATE PATTERN OF LAND USE IN UNITS OF SAN JOAQUIN AREA

(In acres)

Class of land use	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit	Totals
Irrigated lands	56,400	88,000	58,600	72,400	275,400
Dry-farmed lands	3,500	7,900	2,100	10,500	24,000
Native vegetation	700	2,900	200	300	4,100
Miscellaneous	12,870	12,000	25,070	11,260	61,200
TOTALS	73,470	110,800	85,970	94,460	364,700

Unit Use of Water

The second step in evaluation of water requirements involved the determination of unit values of consumptive use of water for each type of water-consuming land use. Estimates of these unit values were based largely on the results of prior investigations and studies in other areas.

A procedure suggested by Harry F. Blaney and Wayne D. Criddle of the Soil Conservation Service, United States Department of Agriculture, in their reports entitled "A Method of Estimating Water Requirements in Irrigated Areas From Climatological Data," dated December, 1947, and "Determining Water Requirements in Irrigated Areas From Climatological and Irrigation Data," dated August, 1950, was generally utilized for adjustment of available data on unit consumptive use by irrigated crops in other localities to correspond with conditions existing in the San Joaquin Area. This method involved correlation of the data on the basis of variations in average monthly temperatures, monthly percentages of annual daytime hours, precipitation, and lengths of growing season. It disregarded certain generally unmeasured factors such as wind movement, humidity, etc. Average monthly temperatures at Stockton were considered representative of the San Joaquin Area. Monthly percentages of annual daytime hours were determined for latitude 38° N. which passes approximately through the center of the area.

The following is an outline of the procedure utilized for estimating unit values of consumptive use of water:

1. The unit value for each irrigated crop during its growing season was taken as the product of available heat and an appropriate coefficient of consumption, where: (a) the available heat was the sum of the products of average monthly temperatures and monthly percent of daytime hours, and (b) the coefficient of consumption was one which had been selected as appropriate for California by Harry F. Blaney as a result of his studies for the Soil Conservation Service. Certain exceptions involved the use of coefficients estimated from consumptive use data from other sources.

2. The unit value for each irrigated crop during its nongrowing season was taken as the amount of precipitation available, but not exceeding one to two inches of depth per month depending on the type of crop.

3. The seasonal unit value for each irrigated crop was taken as the summation of values determined under items 1 and 2 for that crop.

4. Unit seasonal values for native annual grasses were taken as the summation of available precipitation up to but not exceeding two inches in depth per month.

5. Unit seasonal values for native vegetation other than annual grasses were estimated on the basis of available data on corresponding consumptive use in similar localities, due consideration being given to density and type of vegetation and depth to ground water.

6. Unit seasonal values for free water surfaces were estimated from available records of evaporation at Lodi.

7. Unit seasonal values for remaining miscellaneous types of land use were estimated on the basis of available data on corresponding consumptive use in similar localities.

Estimated unit seasonal values of consumptive use of water in the San Joaquin Area, including values for consumption of both applied water and precipitation, are presented in Table 33. In view of the indi-

Rice Field in San Joaquin Area

TABLE 33

ESTIMATED UNIT VALUES OF SEASONAL CONSUMPTIVE USE OF WATER IN SAN JOAQUIN AREA

(In feet of depth)

Class and type of land use	Average for 12-year base period, 1939-40 through 1950-51			1948-49			1951-52		
	Applied water	Precipitation	Total	Applied water	Precipitation	Total	Applied water	Precipitation	Total
Irrigated lands									
Permanent pasture	2.55	1.11	3.66	2.73	0.92	3.65	2.58	1.20	3.78
Vineyard	1.19	1.06	2.25	1.35	0.86	2.21	1.17	1.11	2.28
Deciduous orchard	1.68	1.19	2.87	1.83	0.86	2.69	1.70	1.24	2.94
Alfalfa	2.45	1.22	3.66	2.65	1.00	3.65	2.33	1.45	3.78
Beans	1.11	0.78	1.89	1.15	0.71	1.86	1.02	0.86	1.88
Tomatoes	1.62	0.86	2.48	1.76	0.78	2.54	1.71	0.84	2.55
Rice	4.60	0.87	5.47	4.67	0.81	5.48	4.66	0.84	5.50
Truck	0.93	0.86	1.79	1.05	0.78	1.83	1.00	0.84	1.84
Asparagus	1.92	0.86	2.78	2.15	0.65	2.80	1.88	0.93	2.81
Sugar beets	1.69	0.87	2.56	1.87	0.73	2.60	1.71	0.90	2.61
Miscellaneous	1.11	0.87	1.98	1.39	0.65	2.04	1.17	0.90	2.07
Dry-farmed fallow lands			1.10			0.96			1.31
Native vegetation	*1.40	1.10	2.50	*1.54	0.96	2.50	*1.19	1.31	2.50
Miscellaneous									
Urban	2.10	1.10	3.20	2.10	0.96	3.06	2.10	1.10	3.20
Farmsteads	0.90	1.10	2.00	1.04	0.96	2.00	0.69	1.31	2.00
Roads			1.00			0.96			1.00
Highways and railroads			1.00			0.96			1.00
Water surface			4.20			4.20			4.20
Waste lands			1.10			0.96			1.31
Swamps			5.00			5.00			5.00

* High-water-table areas.

cated water supply and climatological similarities of the mean and base periods, the estimated average unit seasonal values of consumptive use for the base period were considered to approximate corresponding values for the mean period.

Past and Present Water Requirements

Water requirements in the San Joaquin Area for the base period and for 1951-52 were estimated by multiplying the average acreage of each type of land use during these periods by its respective unit value of consumptive use of water, as given in Table 33. The results of the estimates of seasonal water requirements during the base period and 1951-52 are presented in Table 34, summarized by general classes of land use.

TABLE 34

ESTIMATED SEASONAL CONSUMPTIVE USE OF WATER IN SAN JOAQUIN AREA DURING BASE PERIOD AND 1951-52 SEASON

(In acre-feet)

Class of land use	Average for 12-year base period, 1939-40 through 1950-51	1951-52
Irrigated lands	399,800	605,700
Dry-farmed and fallow lands	214,700	176,700
Native vegetation	11,900	10,200
Miscellaneous	62,000	83,700
TOTALS	688,400	876,300

These estimates include consumptive use of precipitation.

The mean seasonal water requirement in the San Joaquin Area was also estimated as it would be with present land use, but under mean conditions of water supply and climate. The estimate was based on the pattern determined by the 1951-52 land use survey, and on estimated average unit seasonal values of consumptive use of water for the 12-year base period which were considered to approximate those for the mean period. The estimate, which includes consumptive use of precipitation, is presented in Table 35, summarized by the four units of the area and segregated by general classes of land use.

TABLE 35

ESTIMATED MEAN SEASONAL CONSUMPTIVE USE OF WATER IN UNITS OF SAN JOAQUIN AREA UNDER PRESENT PATTERN OF LAND USE

(In acre-feet)

Class of land use	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit	Total
Irrigated lands	158,300	142,900	126,800	165,800	593,800
Dry-farmed and fallow lands	18,300	52,000	26,600	52,700	149,600
Native vegetation	1,700	7,200	600	700	10,200
Miscellaneous and urban	11,500	16,900	47,100	7,700	83,200
TOTALS	189,800	219,000	201,100	226,900	836,800

In order to facilitate certain phases of the analysis of ground water hydrology, presented in Chapter II, it was desirable to estimate seasonal consumptive use of applied ground and surface water and of precipitation in the San Joaquin Area. To this end, appropriate unit values of consumptive use of applied water were multiplied by the acreages of each type of land use served respectively by ground water and surface water. Consumption of precipitation was evaluated as the difference between total consumptive use of water and utilization of applied water. The estimates were made for the seasons of 1948-49 and 1951-52, for the average for the base period from 1939-40 through 1951, and for present land use under mean conditions of water supply and climate. The 1951-52 pattern of land use was considered representative of present conditions, and average unit seasonal values of consumptive use for the base period were considered to be equal to corresponding mean period values. The estimates are summarized by general classes of land use in Table 36.

TABLE 36

ESTIMATED SEASONAL CONSUMPTIVE USE OF APPLIED SURFACE AND GROUND WATER AND PRECIPITATION IN SAN JOAQUIN AREA

(In acre-feet)

Class of land use	1948-49	1951-52	Average for 12-year base period, 1939-40 through 1950-51	With present land use under mean conditions of water supply and climate
Surface water				
Irrigated lands	72,000	80,800	64,100	76,300
Miscellaneous	0	0	0	0
Subtotals	72,000	80,800	64,100	76,300
Ground water				
Irrigated lands	269,500	311,500	189,100	317,100
Miscellaneous	43,300	44,300	34,200	46,100
Subtotals	312,800	355,800	223,300	363,200
Precipitation				
Irrigated lands	143,000	213,400	146,600	200,400
Miscellaneous	198,600	226,300	254,400	196,900
Subtotals	341,600	439,700	401,000	397,300
TOTALS	726,400	876,300	688,400	836,800

Probable Ultimate Water Requirement

The total water requirement in the San Joaquin Area was estimated as it would be with the probable ultimate pattern of land use and under mean conditions of water supply and climate. This was accomplished by multiplying acreages derived in the forecast of the ultimate pattern of land use by corresponding average unit seasonal values of consumptive use of water for the base period. It was considered that unit consumptive use during the base period was equal to that under mean conditions of water supply and climate. The estimate of probable ultimate water requirement is summarized in Table 37 by general classes of land use. The estimate includes consumptive use of precipitation.

TABLE 37

PROBABLE ULTIMATE MEAN SEASONAL CONSUMPTIVE USE OF WATER IN UNITS OF SAN JOAQUIN AREA

(In acre-feet)

Class of land use	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit	Totals
Irrigated lands	183,300	277,200	166,600	307,000	934,100
Dry-farmed lands	3,900	8,700	2,300	11,500	26,400
Native vegetation	1,700	7,200	500	700	10,100
Miscellaneous and urban	34,900	24,200	65,100	26,800	151,000
Totals	223,800	317,300	234,500	346,000	1,121,600

Nonconsumptive Water Requirements

As has been stated, certain nonconsumptive requirements for water, such as those for hydroelectric power generation, flood control, recreation, and conservation of fish and wildlife, will be of significance in the design of works to meet consumptive requirements for water in the San Joaquin Area. In most instances the magnitudes of the nonconsumptive requirements are relatively indeterminate, and are dependent upon allocations made during design of the works and after consideration of economic factors. Water requirements for hydroelectric power production, flood control, recreation, and conservation of fish and wildlife are discussed in general terms in this section, but not specifically evaluated.

Hydroelectric Power Production. Because of the relatively low topographic relief throughout the San Joaquin Area, hydroelectric power production within the area is not of major significance. However, the principal nonconsumptive water requirement in watersheds tributary to the San Joaquin Area is that which pertains to the generation of hydroelectric energy. Although this requirement generally does not result in the consumption of water nor in the depletion of runoff, it is a fundamental consideration in the development and distribution of water.

In yield studies for possible new projects involving hydroelectric power plants, subsequently presented in this bulletin, water was released through the proposed plants on the basis of an irrigation demand schedule. Thus the requirements for hydroelectric energy generation were considered to be incidental to the requirements for irrigation and other beneficial consumptive uses of water. However, revenues from the sale of hydroelectric energy from such projects would serve in many instances to make irrigation and other features of the projects economically and financially feasible.

Flood Control. Destruction and havoc caused by floods in California have frequently been accompanied by the economic anomaly of wastage of large amounts of water from areas of deficient water supply. Storage of such flood waters in upstream reservoirs would have accomplished the dual purpose of conservation of needed water and reduction of flood damages. Results of the State-wide Water Resources Investigation to date indicate that if California is to attain growth and development commensurate with her manifold resources, nearly all of the potential reservoir storage capacity of the State must be constructed and dedicated to operation for water conservation purposes. This in itself will result in a substantial increase in downstream flood protection. However, any portion of the available reservoir storage capacity that is operated wholly or partially for flood control purposes will correspondingly reduce the capacity available for conservation.

Damages from floods in the San Joaquin Area occur periodically on flatlands adjacent to the Mokelumne and Calaveras Rivers, and Dry, Bear, and Littlejohns Creeks. However, Hogan Dam and Reservoir on the Calaveras River and Farmington Dam and Reservoir on Littlejohns Creek provide substantial flood protection to areas downstream from the reservoirs and to the City of Stockton. Conservation works on the Mokelumne River afford a measure of flood control on that stream, but this control has been insufficient in the past to prevent flood damage, particularly from large floods. No flood control works of significance exist on Dry or Bear Creeks. Additional works for protection from floods have been authorized by the Federal Government and by the State of California on Bear Creek, Calaveras River, and Littlejohns Creek.

In preliminary design of certain works to meet the present and probable ultimate supplemental water requirements of the San Joaquin Area, consideration was given to additional provisions for flood control and protection. For such new works it was assumed that the Federal Government would contribute a sum to the costs of the works equivalent to the direct flood control benefits in the interest of flood control.

Recreation and Fish and Wildlife. With anticipated continued growth in population of California, it is expected that the public demand for preservation and enhancement of recreational facilities will be sufficient to assure provision of water supplies necessary for such purposes. In the aggregate the amount of water used for domestic and service facilities in recreational areas in watersheds tributary to the San Joaquin Area is relatively small. As for waters employed for boating, swimming, and other water sports, most are available naturally or as a result of works constructed and operated for other purposes, and the nonconsumptive recreational use of the water is incidental to the other uses. Of considerable importance among the employments of water for recreational purposes are those associated with the preservation and propagation of fish and wildlife.

So far as is known, no artificial lakes in watersheds tributary to the San Joaquin Area are utilized exclusively for fish life, such use being incidental to the primary purposes for which the reservoirs were constructed. However, the levels of a few small natural lakes on the headwaters of streams have been raised by the State Department of Fish and Game, and releases are made to maintain downstream flow conditions favorable to the preservation and propagation of fish life. It is considered probable that in the future more reservoir storage capacity will be allocated to this purpose, and that in some instances reservoirs will be constructed exclusively to augment natural low summer and fall stream flows in the interests of fish life.

Water released down a stream to maintain the minimum flow required for fish life does not constitute a consumptive use of the water. The demands of fish life, however, are frequently incompatible with hydroelectric power development and diversion and use of the water for other beneficial purposes. Nevertheless, it is believed that an improved and adequate stream fishery can be developed and maintained by the construction of upstream storage to improve low stream flow conditions. In addition, reservoirs constructed to regulate stream flow for other purposes will provide a greatly increased lake fishery.

In connection with reservoir yield studies made for the San Joaquin County Investigation, no releases of water for fish, wildlife, and recreation were made on Dry Creek or the Calaveras River. It was assumed that sufficient water for these purposes would be available in the Mokelumne River because of leakage from Woodbridge Dam and return flow downstream therefrom. A maximum release of 75 second-feet for stream flow maintenance was made in yield studies for reservoirs on the Stanislaus River.

Factors of Water Demand

The term "factors of water demand," as used in this bulletin, refers to those factors pertaining to rates, times, and places of delivery of water, losses of water, quality of water, etc., imposed by the control, development, and use of the water for beneficial purposes. Irrigation practice in the San Joaquin Area, as determined by rates of application, irrigation efficiencies, gross diversions, monthly demands,

Walnut Grove Near Linden

and permissible deficiencies in application of water, must be given consideration in preliminary design of works to meet supplemental water requirements. These factors of demand, which were not measured or considered in the foregoing estimates of water requirements, are discussed in the following sections.

Application of Water. The term "applied water," as used in this bulletin, refers to that water other than precipitation which is delivered to a farmer's headgate or by his well and pump, in the case of irrigation use, or which is delivered to an individual's meter in the case of urban use, or its equivalent. During each season of the investigation measurements were made of the amount of water applied for irrigation of selected plots of principal crops grown on various soil types in the San Joaquin Area. Records of such application of water pumped from wells were obtained for 35 plots during 1947-48, 51 plots in 1948-49, 26 plots in 1949-50, and 23 plots during 1950-51. For each well the pump discharge, acreage of each type of crop irrigated, and rate of power consumption were recorded. From these data, monthly and total seasonal applications of water to each crop were determined. Results of these studies, which may be considered representative of prevailing ground water irrigation practice in the San Joaquin Area, are summarized in Table 38. Detailed results of the plot studies are presented in Appendix H, and locations of the plots are indicated on Plate 15.

Irrigation Efficiency. Studies were made to determine the approximate average irrigation efficiency realized from application of ground water in the San Joaquin Area. "Irrigation efficiency" is defined as the ratio of consumptive use of applied water to the total amount of applied water, and is commonly expressed as a percentage.

The season of 1948-49 was selected for these studies, since in that season the coverage of plot studies of application of water was the most comprehensive. In order to estimate the total amount of ground water applied for irrigation, appropriate crop acreages, as mapped during the 1949 land use survey, were multiplied by average seasonal values of depth of applied water for the several crops, as measured at the representative plots shown in Table 38. However, in the case of the Littlejohns Unit, average unit values of applied water obtained during the 1949-50 season were multiplied by the 1948-49 crop acreages, as no use of water studies were made during the 1948-49 season in that unit. The computation of applied ground water in the San Joaquin Area resulted in an estimate of 381,000 acre-feet. As a check on this figure, the Pacific Gas and Electric Company furnished a corresponding estimate of 397,000 acre-feet of ground water pumped during the 1948-49 season, based on records of electric power consumption for pumping. The company's estimate gave consideration to the relationship between pumping plant horsepower, drawdown, and power consumption per unit of water pumped at various lifts, as determined by pump performance tests conducted in the area by the company. In view of the nature of the basic data, the check furnished was believed to have been very close.

By dividing the estimated value of approximately 269,000 acre-feet for consumptive use of ground water on irrigated lands in the San Joaquin Area in 1948-49, presented in Table 36, by the foregoing estimated value of 381,000 acre-feet, it was estimated that the irrigation efficiency realized from the application of ground water in the San Joaquin Area in 1948-49 was approximately 70 per cent. It was impractical to make a corresponding estimate of irrigation efficiency

TABLE 38

MEASURED SEASONAL APPLICATION OF GROUND WATER ON REPRESENTATIVE PLOTS OF PRINCIPAL CROPS IN SAN JOAQUIN AREA

Crop	Number of plots					Applied water, in feet of depth				
	1947-48, Calaveras Unit	1948-49, Western Mokelumne, Eastern Mokelumne, and Calaveras Units	1949-50, Western Mokelumne, Eastern Mokelumne, and Littlejohns Units	1950-51, Littlejohns Unit	Total	1947-48	1948-49	1949-50	1950-51	Weighted average for the four seasons
Alfalfa	4	7	6	6	23	2.94	2.97	3.95	3.77	3.59
Beans	5	4	1	--	10	1.68	1.68	2.26	----	1.74
Deciduous orchard	9	14	5	2	30	2.90	2.59	2.54	1.61	2.68
Permanent pasture	4	6	4	9	23	2.77	3.69	3.29	4.12	3.57
Rice	1	--	1	4	6	8.15	----	12.36	8.37	8.98
Sugar beets	1	5	1	--	7	1.63	2.47	1.55	----	2.13
Tomatoes	4	3	1	2	10	2.03	1.82	2.19	1.66	1.94
Truck	7	--	--	--	7	1.61	----	----	----	1.61
Vineyard	--	12	7	--	19	----	1.60	2.01	----	1.77

Vineyard Near Lodi

realized from use of surface water in the San Joaquin Area because of lack of sufficient data regarding application of surface water for irrigation purposes.

Gross Diversion of Water. The amount of the gross diversion for irrigation by ground water in the San Joaquin Area was considered to be equivalent to the amount of applied ground water. As discussed in the preceding section, this was estimated to have been 381,000 acre-feet during 1948-49. An estimate of the gross diversion for irrigation by ground water in the San Joaquin Area during 1951-52 was also made, by multiplying the weighted average depth of applied water for each crop, as shown in Table 38, by respective acreages as determined from the 1951-52 land use survey, shown in Table 30. The amount, so determined, was about 468,000 acre-feet.

The gross diversion for irrigation by surface water in the San Joaquin Area was estimated to have totaled about 183,000 acre-feet during the 1948-49 irrigation season, and 182,000 acre-feet during the 1951-52 season. These quantities were determined both from records of measured diversions and from estimates based on those records.

By subtracting from the estimate of total consumptive use of water on irrigated lands the corresponding estimate of consumptive use of ground water and precipitation, the approximate amount of consumptive use of applied surface water was estimated. An estimate of total consumptive use of water on irrigated lands of the San Joaquin Area in 1951-52 in the amount of approximately 606,000 acre-feet was presented in Table 34. Consumptive use of ground water on irrigated lands was estimated to have been about 312,000 acre-feet in 1951-52, as shown in Table 36. It was further estimated that consumptive use of precipitation on the 189,930 acres of irrigated lands in the San Joaquin Area in 1951-52 was equal to 1.12 feet of depth, or a total of about 213,000 acre-feet. It follows that the estimated amount of consumptive use of surface water applied for irrigation in the area was approximately 81,000 acre-feet in 1951-52.

It is evident from the foregoing that only about 81,000 acre-feet or about 45 per cent of the estimated 182,000 acre-feet of gross surface diversion for irrigation in the San Joaquin Area in 1951-52 was actually consumed in the production of crops. It should be noted that this figure is not comparable with estimated irrigation efficiency attained in connection with use of ground water in the area, evaluated in the preceding section, since it is based on the amount of gross diversion rather than on the amount of applied water. Insufficient data were available to permit evaluation of transmission and other losses encountered in connection with use of surface water between points of diversion and places of use. Furthermore, this figure does not fully represent the relationship of consumptive use of applied surface water on specific lands, to gross surface diversions for such lands, since some of these lands receive only a partial supply from surface sources. The remainder of the supply required for these lands is obtained from ground water.

Monthly Demands for Irrigation Water. Because of the wide variety of crops produced in the San Joaquin Area there is considerable variation in both rate and period of demand for irrigation water. On the average, the irrigation demand occurs during the months of April through October. Studies of irrigation practice in the San Joaquin Area indicated that for certain crops the maximum monthly demand might be as much as 40 per cent of the seasonal total. Based on these studies, and on similar studies made in other areas, the estimated average monthly distribution of demand for irrigation water in the San Joaquin Area is set forth in Table 39. Early applications of water to irrigated pasture and rice account for the greater part of the demand for water in April and May.

TABLE 39

ESTIMATED AVERAGE MONTHLY DISTRIBUTION OF DEMAND FOR IRRIGATION WATER IN SAN JOAQUIN AREA

(In per cent of seasonal total)

Month	Surface water	Ground water	Weighted average
October	7	3	4
November	0	0	0
December	0	0	0
January	0	0	0
February	0	0	0
March	0	2	1
April	10	8	8
May	14	15	15
June	20	22	21
July	19	22	22
August	18	19	19
September	12	9	10

Permissible Deficiencies in Application of Irrigation Water. Studies to determine deficiencies in the supply of irrigation water that might be endured without permanent injury to perennial crops were not made in connection with the San Joaquin County Investigation. However, the results of past investigation and study of endurable deficiencies in the Sacramento River Basin are believed to be applicable to the San Joaquin Area. In this respect, the following is quoted from Division of Water Resources Bulletin No. 26, "Sacramento River Basin," 1931.

> "A full irrigation supply furnishes water not only for the consumptive use of the plant but also for evaporation from the surface during application and from the moist ground surface, and for water which is lost through percolation to depths beyond the reach of the plant roots. Less water can be used in years of deficiency in supply by careful application and by more thorough cultivation to conserve the ground moisture. In these ways the plant can be furnished its full consumptive use with much smaller amounts of water than those ordinarily applied and the yield will not be decreased. If the supply is too deficient to provide the full consumptive use, the plant can sustain life

on smaller amounts but the crop yield will probably be less than normal.

"It is believed from a study of such data as are available that a maximum deficiency of 35 per cent of the full seasonal requirement can be endured, if the deficiency occurs only at relatively long intervals. It is also believed that small deficiencies occurring at relatively frequent intervals can be endured."

In the selection of sizes of conservation works for design purposes to service the San Joaquin Area, it was assumed that deficiencies in the amount of 35 per cent of the average seasonal requirement for irrigation water may be endured in seasons of critically deficient water supply, provided that such deficienices do not occur frequently. It was further assumed that requirements for urban water and hydroelectric power would be met at all times without deficiency.

SUPPLEMENTAL WATER REQUIREMENTS

The previously presented data, estimates, and discussion regarding water supply and utilization in the San Joaquin Area indicate that present and probable future water problems of the area are largely limited to those connected with ground water, and that their effects are largely related to irrigated agriculture and municipal development in the vicinity of Stockton. It is further indicated that ground water problems created in various portions of the area by progressive lowering of water levels may be limited or prevented if adequate supplemental water supplies are developed and utilized in the area. The estimated present and probable ultimate requirements for supplemental water in the San Joaquin Area are discussed and evaluated in the following sections. For purposes of this bulletin, requirements for supplemental water refer to the amount of water, over and above the sum of safe ground water yield and safe surface water yield, which must be developed to satisfy these requirements. Water requirements in turn refer to the amount of water needed to provide for all beneficial consumptive uses of water and for irrecoverable losses of water incidental to such beneficial use. It is emphasized that the following estimates of supplemental water requirements were based on the water supply which was available to the San Joaquin Area during the base period. However, as was pointed out in Chapter II, the amount of this supply was affected by upstream water utilization, operation of upstream reservoirs, and by upstream diversions for export from the tributary watersheds. To the extent that consumptive use in and exports from these watersheds are increased, the water supply available to the area is correspondingly reduced and supplemental water requirements are increased.

Present Supplemental Water Requirement

The present requirement for supplemental water in the San Joaquin Area was evaluated as the difference between safe yield of ground water and present consumptive use of ground water. It might be argued that this evaluation fails to give consideration to possible inadequacies in service of surface water to portions of the area. However, in the solution of the equation of hydrologic equilibrium, presented in Table 17, upon which the estimate of safe ground water yield was based, the unit consumptive use factors chosen assumed a full and sufficient application of water on all irrigated lands whether from surface sources or ground water. It follows that any possible present inadequacy in surface water service was taken into account and provided for in the estimate of safe ground water yield.

It was estimated in Chapter II that safe seasonal ground water yield in the San Joaquin Area amounted to 265,800 acre-feet. This was determined as the seasonal net extraction of water from the ground water basin that might be maintained, under mean conditions of water supply and climate, without further progressive lowering of the water table below average levels prevailing during the three-year period from 1949-50 through 1951-52. Seasonal consumptive use of ground water in the area, with the present pattern of land use and under mean conditions of water supply and climate, was estimated to be 363,200 acre-feet, as shown in Table 36. The estimated present requirement for supplemental water in the San Joaquin Area, therefore, is some 97,400 acre-feet per season. This estimate is presented in Table 40, which shows distribution of the supplemental water requirement among the several units of the area. The distribution was based on the determined difference between consumptive use of ground water under mean conditions of water supply and climate, and safe ground water yield for each unit of the area.

TABLE 40

ESTIMATED PRESENT MEAN SEASONAL SUPPLEMENTAL WATER REQUIREMENT IN UNITS OF SAN JOAQUIN AREA

Unit	Acre-feet
Western Mokelumne	0
Eastern Mokelumne	28,500
Calaveras	18,400
Littlejohns	50,500
TOTAL	97,400

The estimate of present supplemental water requirement in the Littlejohns Unit, presented in Table 40, reflects the recent large increase in lands devoted to irrigated agriculture. Measurements of depth to ground water in the fall of 1952 and fall of 1953 indicate that the weighted average level of ground water during this period dropped about 7.0 feet. The attendant change in ground water storage for this lowering was about 44,000 acre-feet. Runoff and precipitation during the season 1952-53 approximated that for the mean. The difference between the estimated mean seasonal supplemental water requirement in the Littlejohns Unit and change in ground water storage during the period from the fall of 1952 to the fall of 1953, 6,500 acre-feet, may be attributed to increase in subsurface inflow due to lowering of ground water levels.

The estimates of present supplemental water requirements, presented in Table 40, were based on the water supply which was available to the San Joaquin Area during the base period. Under the assumption that the East Bay Municipal Utility District, the Calaveras Public Utility District, and the Pacific Gas and Electric Company through its Amador Canal would have increased their seasonal diversions from the Mokelumne River to 224,000 acre-feet, 9,000 acre-feet, and 15,000 acre-feet, respectively, and under a method of operation of Pardee Reservoir proposed by the East Bay Municipal Utility District, and under the further assumption that the present maximum monthly rate of diversion from the Mokelumne River by the Woodbridge Irrigation District, in accordance with the demand schedule set forth in Table 39, was 450 second-feet in July, it was estimated that the resultant average seasonal diversion which could have been made by the irrigation district, for the period from 1924 through 1951, would have been but 57 per cent of the full seasonal demand of 149,000 acre-feet, or about 85,000 acre-feet. In the following tabulation the effect of the foregoing may be noted. The estimated resultant water supply that would have been available monthly, as measured in per cent of the full monthly demand, is presented for the dry season of 1931, the wet season of 1942, and the average season for the period from 1924 through 1951.

ESTIMATED AVAILABLE MONTHLY WATER SUPPLY, IN PER CENT OF MONTHLY DEMAND

Season	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*Seasonal total*
1931	20	20	20	20	20	20	20	20
1932	100	100	100	100	44	56	60	80
Average 1924-51	86	83	79	40	31	41	50	57

Based on the estimates presented in the foregoing tabluation, the total seasonal water supplies that would have been available to the Woodbridge Irrigation District in 1931, 1942, and the average seasonal supply for the period from 1924 through 1951, would have been 30,000 acre-feet, 119,000 acre-feet, and 85,000 acre-feet, respectively. Based on an estimated full seasonal requirement of 149,000 acre-feet, the shortages in supply for 1931, 1942, and the average for the period from 1924 through 1951, would have been 119,000 acre-feet, 30,000 acre-feet, and 64,000 acre-feet, respectively. These shortages could in part be reduced by conservation of surface outflow from the Western Mokelumne Unit, which in 1951-52 was measured and found to be about 28,500 acre-feet.

Estimates of supplemental water requirements for the San Joaquin Area were based on the measured and estimated amount of water which was historically available to the area during the chosen base period, modified to represent present conditions. Under such conditions, certain water could be salvaged in the Western Mokelumne Unit and made available to meet supplemental water requirements therein.

Table 19 indicates that under mean conditions of water supply and climate, and present conditions of development, surface outflow and subsurface outflow from the Western Mokelumne Unit amount to 37,000 acre-feet and 32,300 acre-feet, respectively.

Subsurface outflow could be salvaged by strategically locating and constructing wells to effect capture of the outflow before it passes beyond the boundaries of the unit. Assuming continuous operation of such wells, discharging an average of 1,000 gallons per minute per well over a six-month period each season, about 41 wells would be required to salvage the estimated seasonal average of 32,300 acre-feet of subsurface outflow.

Subsurface outflow from the Western Mokelumne Unit passes beyond the unit to the Eastern Mokelumne Unit, Calaveras Unit, and the Delta. Of the total average seasonal subsurface outflow of 32,300 acre-feet, it was estimated that about 4,500 acre-feet flows into the Eastern Mokelumne Unit, 8,800 acre-feet into the Calaveras Unit, and the remainder, 19,000 acre-feet, flows into the Delta. The salvage of such water in the Western Mokelumne Unit would increase the estimates of supplemental water requirements presented in Table 41 by 4,500 acre-feet for the Eastern Mokelumne Unit and 8,800 acre-feet for the Calaveras Unit.

Probable Ultimate Supplemental Water Requirement

The probable ultimate requirement for supplemental water in the San Joaquin Area was evaluated as the difference between present and probable ultimate consumptive use of water, plus the present requirement for supplemental water. Development and utilization of a supplemental water supply in the amount of this forecast would assure an adequate supply of water for lands presently irrigated in the area, as well as for those irrigable lands not presently served with water. Furthermore, present problems resulting from progressive lowering of ground water levels would be eliminated.

Estimates of present and probable ultimate consumptive use of water in the San Joaquin Area, under mean conditions of water supply and climate, were presented in Tables 35 and 37, respectively, and a

(Courtesy of Stockton Chamber of Commerce)

Covercropped Deciduous Orchard in San Joaquin Area corresponding estimate of the present requirement for supplemental water was developed in the preceding section. Utilizing these estimates, the forecast of probable ultimate seasonal requirement for supplemental water by units of the San Joaquin Area, under mean conditions of water supply and climate, is presented in Table 41.

TABLE 41

PROBABLE ULTIMATE MEAN SEASONAL SUPPLEMENTAL WATER REQUIREMENT IN UNITS OF SAN JOAQUIN AREA

(In acre-feet)

Unit	1 Present consumptive use of water	2 Probable ultimate consumptive use of water	3 Probable increase in consumptive use of water (2–1)	4 Present supplemental water requirement	5 Probable ultimate supplemental water requirement (3 + 4)
Western Mokelumne	189,800	223,800	34,000	0	34,000
Eastern Mokelumne	219,000	317,300	98,300	28,500	126,800
Calaveras	201,100	234,500	33,400	18,400	51,800
Littlejohns	226,900	346,000	119,100	50,500	169,600
TOTALS	836,800	1,121,600	284,800	97,400	382,200

LEGAL CONSIDERATIONS

The foregoing estimates of supplemental water requirements for the San Joaquin Area were based on the measured and estimated amount of water which was historically available to the area during the chosen base period. However, the amount of this supply was affected by upstream uses of water, operation of upstream reservoirs, and upstream diversions for export from the tributary watersheds. It is emphasized that, to the extent that water is consumptively used in and exported from these watersheds, the water supply available to the San Joaquin Area is correspondingly reduced. Thus, an increase in the amount of such use and export would increase the supplemental water requirements of the area over the amounts estimated herein.

Development and utilization of water in the tributary watersheds, operation of the upstream reservoirs, and diversion for export from those watersheds, are subject to the provisions of existing agreements and court decrees, and possibly to water rights not considered in those agreements and decrees. Existing rights to the use of waters of the streams in and tributary to the San Joaquin Area have never been the subject of a comprehensive adjudication wherein the right of each user has been determined as against each and every other user. In the absence of such adjudication no right has been established conclusively beyond attack by anyone. However, certain rights to store and divert water of the Mokelumne and Stanislaus Rivers have been the subject of court decrees and of private agreements. The decrees are binding upon the parties to the litigation and persons acting in privity with them, while the agreements are likewise effective among the parties thereto and their successors in interest, but may be modified by mutual consent. The following summary of the decrees and agreements is believed to be factually accurate but does not express conclusions regarding the legal effect or validity of water rights referred to therein.

Mokelumne River

In *City of Lodi* v. *East Bay Municipal Utility District, et al.*, San Joaquin County Superior Court No. 22415, a final judgment was entered in 1938 after a prior judgment had been reversed on appeal. (See 7 Cal. 2d 316.) The right of the Pacific Gas and Electric Company to divert from the North Fork so much water as may reasonably be required (not to exceed 30 second-feet) for municipal, domestic, and other beneficial uses in the Cities of Jackson and Sutter Creek and their vicinities, and to make certain other diversions of water for power purposes to be returned to the stream, was declared and recognized as prior to any rights of the City of Lodi. The right of the city to 3,600 acre-feet of water per annum was adjudged prior to any other claim of the company and was prior to any right of the utility district. Provision was made for protection of the city's right against impairment by reason of storage and diversion by the district. The company was also adjudged to have certain additional rights by virtue of permits granted by the Division of Water Rights to store water for generation of power, and the company was required, so long as it uses the Salt Springs, Lower Bear River, or Deer Valley Reservoirs, to impound in said reservoirs, if and when constructed, sufficient water to fill said reservoirs to their capacities and to release the impounded waters according to certain provisions contained in the judgment. Subject to the priorities of the city and to the obligations of the utility district to maintain said priorities, it was adjudged that the district owns the right to divert 310 second-feet at Pardee Reservoir all year for municipal and domestic uses and to store in said reservoir from October 1st to July 15th, for like purposes, 217,000 acre-feet of water, provided that the combined diversions directly and from storage shall not exceed 310 second-feet or approximately 200 million gallons per day. The utility district was further adjudged to have the right to store and use water for power purposes, all such water to be returned to the river.

On July 25, 1940, a stipulated judgment was rendered in an action in the Superior Court of Calaveras County, entitled *East Bay Municipal Utility District* v. *Pacific Gas and Electric Company*, No. 1950. The company's rights, substantially as set forth in the judgment in the Lodi case (but limiting diversions for other than power use to 15,000 acre-feet per annum) were decreed to be prior to the rights of the district, subject to the obligation of the company to return to the stream all of the water diverted or stored by it for generation of power. Certain releases from storage were provided to be made by the company in accordance with a schedule similar to but varying in some respects from the provisions of the judgment in the *Lodi* case. The rights of the district under its Application No. 4228 to store and divert water at Pardee Reservoir were set forth. The company was enjoined from diverting or storing any of the waters of the Mokelumne River except in substantial conformity with the terms of the judgment.

An agreement was executed between the East Bay Municipal Utility District and the Woodbridge Irrigation District, dated January 7, 1938. It recognized the priority of old appropriative rights of the irrigation district prior to the Water Commission Act, in amounts varying from 30,000 to 45,000 acre-feet per annum, depending upon the flow of water in the Mokelumne River at Pardee Reservoir. The utility district agreed to releases of water from Pardee to insure delivery of sufficient water to the head of the irrigation district's canal to satisfy the prior rights of the irrigation district. The right of the utility district was recognized to the use of water under its applications with the Division of Water Resources numbered 4228, 4768, 5128, and 5002, subject to the old rights of the irrigation district. The right of the Woodbridge Irrigation District under its Application 5807 was stipulated to be junior to the foregoing rights of the utility district.

An agreement dated the 8th day of May, 1940, was entered into between the Calaveras Public Utility District and the East Bay Municipal Utility District. It is therein provided that the Calaveras District has prior right to divert from the South Fork of the Mokelumne River, as augmented by diversions from the Middle and Licking Forks of said river, not to exceed 12.5 second-feet of water for industrial, domestic, mining, and agricultural uses within the boundaries of said district, that the storage or diversion by the Calaveras District of any waters in excess of the foregoing amount shall be subordinate to the right of the East Bay District to store and divert waters for municipal, domestic, and other purposes, except power purposes, and to the rights included in Application 4228 of said East Bay District; that any diversion or storage by the Calaveras District for the generation of power shall be subordinate to the rights of the East Bay District under said application and also to any filings of the latter district for power purposes; that the power filings of the East Bay District shall be subordinate to the storage and diversions by the Calaveras District for domestic, industrial, agricultural, and mining uses but shall not be subordinate to any storage or diversion by the Calaveras District for generation of power.

According to water stage recorder records of the East Bay Municipal Utility District, the maximum actual diversion of water by the Pacific Gas and Electric Company through the Amador Canal for use in the Cities of Jackson and Sutter Creek and vicinities during the period 1947-48 through 1951-52 has been 6,967 acre-feet per annum.

The contract right of the Calaveras Public Utility District to divert 12.5 second-feet of water from the South Fork has no stated maximum amount in acre-feet per annum. A continuous flow of the stipulated amount would equal 9,050 acre-feet in one year. However, a flow of 12.5 second-feet is not available at all times at this source and, according to discharge measurements made by the East Bay Municipal Utility District, during the period 1947-48 through 1951-52 the maximum actual diversion through the Calaveras Canal has been 6,324 acre-feet per annum.

Permit 2459 issued to the East Bay Municipal Utility District upon its Application 4228 authorizes an appropriation of not to exceed 310 second-feet, of which amount the diversions by the district in recent years have averaged approximately 150 second-feet, leaving an expected average increase of some 160 second-feet to be diverted from the watershed under this permit.

On July 30, 1927, the California Department of Finance filed Applications 5647 and 5648 with the Division of Water Rights for appropriation of 1,820 second-feet by direct diversion and 190,000 acre-feet of water to storage from the Mokelumne River and tributaries. The place of intended use described in the applications is upstream from the San Joaquin Area. These applications may be assigned, or their priority may be released in favor of subsequent applications to the extent such assignment or release would be for the purpose of development not in conflict with the general or coordinated plan for which the applications of the Department of Finance were made, and would not deprive the county in which the water originates of any water necessary for the development of the county. (See Water Code Sections 10504, 10505.)

Applications to appropriate water, other than those referred to in the foregoing agreements and decrees, have been filed with the Division of Water Resources. Some of these may form the basis for claims to the future right to store water or to export it from the watershed. Applications to appropriate water in and adjacent to the San Joaquin Area are listed in the tabulation presented as Appendix G to this bulletin.

Stanislaus River

The appropriative rights in and to the use of water of the Stanislaus River stream system initiated prior to December 19, 1914, the effective date of the Water

Commission Act, were determined in the Stanislaus River Adjudication Proceeding. That proceeding was initiated by petition filed by the Oakdale and South San Joaquin Irrigation Districts in 1917, and decree was entered by the Superior Court of San Joaquin County in action No. 16873, on November 15, 1929. The decree was subsequently modified by order entered on February 24, 1930, and by supplemental decrees entered on March 8, 1934, and May 8, 1935, respectively. As modified, the decree awarded water rights to the extent of 2,558.8 second-feet direct flow diversion and 45,925 acre-feet per annum storage, to 42 owners. Of the amounts awarded, 2,525.3 second-feet, and the entire 45,925 acre-feet, were allocated among 4 owners. These were the Melones Mining Company, Oakdale and South San Joaquin Irrigation Districts, Sierra and San Francisco Power Company, and Emma Rose and Hobart Estate Company. The interests of the two latter parties are now owned by the Pacific Gas and Electric Company and include the Tuolumne and Utica ditch systems. The remaining 33.5 second-feet were allocated among 38 owners.

The rights determined in the proceeding have priorities extending from 1850 through 1914, and all except one cover diversions from the Stanislaus River stream system at or above the irrigation districts' Goodwin Dam near Knights Ferry. Only the diversions by the irrigation districts and the power company, including the Tuolumne and Utica ditch systems, cause any appreciable impairment of the natural flow of the Stanislaus River. The other diversions from the stream system are small or are for nonconsumptive uses.

Numerous appropriations from the Stanislaus River stream system have been initiated subsequent to 1914 by applications for permits under the provisions of the Water Code. Many of these have been consummated, others are in the permit stage, and some are still pending. These applications are listed in Appendix G. In the aggregate, a preponderance of these appropriations are for small amounts of water, while the bulk of the water appropriated or sought to be appropriated is confined to a relatively few filings by the irrigation districts and the power company. Certain of the completed and permitted appropriations are exercised to supplement use under the rights determined in the adjudication proceeding. As is the case with the older appropriations, only the diversions under the new appropriations by the irrigation districts and the power company cause any substantial impairment of the natural flow of the Stanislaus River.

The rights set forth in the decree and those subsequently initiated under the provisions of the Water Code give a complete record of the vested rights on the Stanislaus River stream system, except for such claims of rights as may exist by reason of riparian ownership. However, since most of the water of the stream system is diverted and used by the irrigation districts and the power company, such diversions as might be made by riparian owners probably would not impair the natural flow of the stream to any great extent.

Pacific Gas and Electric Company System Rights. All hydroelectric developments on the Stanislaus River stream system are now owned by the Pacific Gas and Electric Company.

The system consists of Phoenix Power Plant on the South Fork, Spring Gap Power Plant on the Middle Fork, and Stanislaus Power Plant below the junction of the North and Middle Forks, Murphys and Angels Power Plants on the North Fork, and Melones Power Plant at Melones Dam on the main stream below the junction of the South Fork, together with numerous storage reservoirs, conduits, and other facilities necessary to the operation.

The flow of the South Fork is regulated by Strawberry Reservoir, having a storage capacity of 18,600 acre-feet and located upstream from the Philadelphia Ditch Intake. A right for the storage of 16,710 acre-feet per annum in Strawberry Reservoir is provided for in the Stanislaus River Decree. A right under Application 1339, filed June 30, 1919, License 1391, permits the diversion of 56.6 second-feet of the natural flow of the South Fork by means of the Philadelphia Ditch for use through the Spring Gap and Stanislaus Power Plants.

Natural flow of the Middle Fork is used through the Stanislaus Power Plant under rights to 300 and 15 second-feet with priorities of 1906 and 1908, respectively, and a right to 160 second-feet, under Application 10122, filed February 19, 1941, License 2862. The flow in the Middle Fork is regulated by storage in Relief Reservoir, amounting to 15,122 acre-feet. Of this total storage, 14,965 acre-feet was allotted in the Stanislaus River Decree with priority of 1905. The water used under these rights is returned to the Stanislaus River, and, for a large portion of each season, constitutes water also included in the vested rights of the Oakdale and South San Joaquin Irrigation Districts.

An appropriation of 1,500 second-feet direct flow diversion, and 132,450 acre-feet per annum storage in Melones Reservoir, for use through Melones Power Plant, was initiated by Application 2460, filed July 29, 1924, upon which License 985 has been issued. The water used under this right is also available for use under the rights of the irrigation districts at Goodwin Dam.

Tuolumne Ditch System Rights. The Tuolumne Ditch system, owned and operated by the Pacific Gas and Electric Company, diverts water from the South

Fork at Lyons Dam for use through the Phoenix Power Plant and for public service purposes in Tuolumne County. As determined in the Stanislaus River Decree, this system is entitled to 52 second-feet direct flow diversion at Lyons Dam with a priority of 1851, and 5,199 acre-feet per annum by storage, of which 4,360 acre-feet has a priority of 1856, and 839 acre-feet a priority of 1897. The decree provides that the stored water is to be used in equalizing the flow of the South Fork of the Stanislaus River at the intake of the Main Ditch to 52 second-feet; that 32 second-feet of the 52 second-feet direct flow or equalized flow diverted through the Tuolumne Main Ditch are to be used for the generation of power at the Phoenix Power Plant; and that said 32 second-feet, together with the remaining 20 second-feet diverted through the Tuolumne Main Ditch, making a total of 52 second-feet, either before or after passing through Phoenix Power Plant, are to be used for public service purposes. The service area of the Tuolumne Ditch system referred to in the decree is now within the boundaries of Tuolumne County Water District No. 2.

The increased storage in Lyons Reservoir is covered by appropriations initiated December 14, 1928, by Applications 6129 and 6130 upon which Licenses 1541 and 1542, respectively, have been issued.

Utica Ditch System Rights. The Stanislaus River Decree sets forth rights to 88 second-feet direct flow of the North Fork and its tributaries for diversion through the Utica Conduit, and 9,000 acre-feet per annum of water of the North Fork to be impounded in Union, Silver Valley, and Utica Reservoirs to be later released and rediverted through the Utica Conduit. The decree provides that the stored water is to be used in equalizing the flow of the North Fork at the intake of the Utica Conduit to a flow of 88 second-feet; that 55 second-feet of the 88 second-feet direct flow or equalized flow diverted through the Utica Conduit are to be used for the generation of power at the Utica Power Plant (Murphys); and that said 55 second-feet together with the remaining 33 second-feet diverted through the Utica Conduit, making a total of 88 second-feet, either before or after passing through Utica Power Plant, are to be used for public service purposes, including domestic, industrial, and irrigation uses. In addition, the decree provides for rights to 25 second-feet from Mill Creek; 56.7 second-feet from Angels Creek; and 8.0 second-feet from Coyote Creek for public service purposes. Water is also supplied to the system under an appropriation of the Pacific Gas and Electric Company initiated by Applications 77A, filed August 4, 1915, and 5414, filed April 11, 1927, upon which permits 1303 and 2957 have been issued for storage in Spicers Meadow Reservoir on Highland Creek of 6,144 and 4,656 acre-feet per annum, respectively. The appropriation under Application 77A was initiated prior to commencement of the Stanislaus River adjudication but after the effective date of the Water Commission Act, and was not included in the adjudication. Spicers Meadow Reservoir, as reported by permittee, has a capacity of about 4,062 acre-feet.

There are many other small rights on Angels, Coyote, Mill, Moran, and Love Creeks, and other tributaries of the Stanislaus River, in addition to those of the Utica Ditch system. These cover diversions for various beneficial uses, including use for the irrigation of about 750 acres in southern Calaveras County.

Oakdale and South San Joaquin Irrigation Districts' Rights. The several rights of the Oakdale and South San Joaquin Irrigation Districts, included in the adjudication, total 1,816.6 second-feet by direct diversion of natural flow at Goodwin Dam near Knights Ferry. These rights were acquired by the districts at the time of their formation in 1909.

In 1918 the South San Joaquin Irrigation District constructed Woodward Dam on Simmons Creek, a tributary of Littlejohns Creek, and under Application 2524, filed August 29, 1921, upon which License 604 has been issued, consummated an appropriation from the Stanislaus River at Goodwin Dam for storage of 36,000 acre-feet per annum in Woodward Reservoir. In 1926 the two districts constructed Melones Dam on the Stanislaus River, nine miles above Goodwin Dam, creating Melones Reservoir to a capacity of 112,500 acre-feet. Under permits issued upon Application 1081, filed September 20, 1918, and Application 3091, filed October 19, 1922, the districts have consummated appropriations of 96,195 and 10,754 acre-feet, respectively, per annum for storage in Melones Reservoir, confirmed by Licenses 2012 and 2013. The districts also have an appropriation initiated by Application 10978, filed February 10, 1945, upon which Permit 6448 has been issued, for 25,000 acre-feet per annum storage in Melones Reservoir. Other appropriations by the districts of the waters of the Stanislaus River were initiated by Application 8892, filed February 3, 1937, and Application 9666, filed July 7, 1939. Licenses 2634 and 2706 have been issued, confirming rights to 7.5 and 6.0 second-feet, respectively. The points of diversion of these appropriations are some 15 or 20 miles downstream from Goodwin Dam.

Rights of the irrigation districts to appropriate water, including storage at the Tulloch, Beardsley, and Donnells sites, for irrigation and power purposes, designated as the Tri-Dam project, were initiated by the filing of Applications 10872, 11105, 12490, 12614, 12873, 13309, and 13310. They were protested by Tuolumne County Water District No. 2, Tuolumne County, Calaveras County Water District, and Calaveras County. These protests were subsequently withdrawn pursuant to agreements between the irrigation districts and protestants. The applications were approved, and Permits 9360 through 9366 were issued to the irrigation districts. Federal Power Commission licenses for hydroelectric development were issued to the irrigation districts in 1950 and 1951.

The agreement between the irrigation districts and Tuolumne County Water District No. 2, dated June 27, 1951, provides in part that the water district shall be entitled to divert water from Donnells Conduit, when constructed by the irrigation districts, during specified periods and under prescribed conditions. The agreement also contains certain restrictions upon the right of the irrigation districts to take water from the South Fork, and the water district agreed to withdraw its then pending applications to appropriate water, insofar as they pertained to the Middle Fork.

Pursuant to request, the Department of Finance on May 18, 1953, assigned to the irrigation districts for the use and benefit of the Tri-Dam project, Application 5648, insofar as it pertains to the Middle Fork of the Stanislaus River, subject to full performance by said districts of all of the obligations and conditions provided to be performed by them by the aforementioned agreement between the irrigation districts and Tuolumne County Water District No. 2, dated June 27, 1951, and further subject to the condition that in the event of abandonment of the project or failure to exercise due diligence in the completion and operation of the same, the assigned rights should revert to the Department of Finance.

CHAPTER IV

PLANS FOR WATER DEVELOPMENT

It has been shown heretofore that the present basic water problems in the San Joaquin Area are the progressive lowering of ground water levels and the threat of attendant degradation of mineral quality of the ground water. Elimination of these problems, prevention of their recurrence in the future, irrigation of irrigable lands not presently served with water, and the provision of additional water for other beneficial purposes, will require further conservation development of available water supplies. In the preceding chapter, estimates were presented as to the amount of supplemental water required for these purposes both at the present time and under probable ultimate conditions of land use.

It has been shown that surplus flows of water are presently available to the San Joaquin Area from the Mokelumne and Calaveras Rivers and from minor tributary streams. Studies which are described in this chapter indicate that the surplus flows, if properly controlled and regulated, could more than meet the present supplemental water requirements of the San Joaquin Area. However, such regulated surplus flows would be insufficient to meet the probable ultimate supplemental water requirements of the area, and under ultimate development it will be necessary to import water to the area from some outside source or sources. Furthermore, solutions to both present and ultimate water problems of the San Joaquin Area must give consideration to vested rights in waters of the tributary streams.

As was stated in Chapter I, the Division of Water Resources is presently conducting surveys and studies for the State-wide Water Resources Investigation, under direction of the State Water Resources Board. This investigation has as its objective the formulation of The California Water Plan, for full conservation, control, and utilization of the State's water resources, to meet present and future water needs for all beneficial purposes and uses in all parts of the State, insofar as practicable. Surveys and studies are also being conducted by the Division of Water Resources for the Survey of Mountainous Areas. This investigation, which is coordinated with the state-wide investigation, has as its primary objective the determination of probable ultimate water requirements of certain counties of the Sierra Nevada.

Although these investigations are still in progress, they are sufficiently advanced to permit tentative description of certain major features of The California Water Plan which could provide supplemental water to meet the probable ultimate requirements of the San Joaquin Area. The projects would also provide supplemental water supplies for other water-deficient areas of California. In addition, benefits from the projects would include hydroelectric power, flood and salinity control, and benefits in the interests of recreation and the preservation of fish and wildlife. Results of the State-wide Water Resources Investigation to date also indicate that if California is to attain growth and development commensurate with its manifold resources, nearly all of the potential reservoir storage capacity of the State must be constructed and dedicated to operation for water conservation purposes.

In general, the major features of The California Water Plan, which were mentioned in the preceding paragraph, would be large multipurpose projects requiring relatively large capital expenditures. Their scope, with regard to both location of the works and benefits derived from their operation, would not be limited to any one local area, but would embrace other large portions of California. Additional study will be required to estimate costs and to determine possible means of financing these large projects. Under the San Joaquin County Investigation, therefore, surveys and studies were made in order to estimate costs of supplemental water supplies for the San Joaquin Area under more localized plans that might be suitable for current financing, construction, and operation by appropriate local public agencies. These plans for initial development generally are such that the works could be integrated into future major projects. For purposes of this bulletin, operation of the planned works was assumed to be limited to conservation of new water supplies sufficient to meet the present supplemental requirements of the San Joaquin Area and to provide for limited future growth in water requirements of the area.

Major features of The California Water Plan that might be pertinent to solution of the ultimate water problems of the San Joaquin Area are described in general terms in this chapter under the heading "The California Water Plan." These projects are or will be more specifically described in other reports of the State Water Resources Board. The several plans for possible initial local development of supplemental water supplies which were given consideration in connection with the San Joaquin County Investigation are described in this chapter under the heading "Plans for Initial Local Development." All such plans considered would be subject to vested rights. Specific plans are presented for the more favorable of these local projects, together with estimates of capital and annual costs and unit costs of the developed supplemental water supplies. Locations of the principal features of the several possible plans, for both initial and future construction, are shown on Plate 14.

In connection with the ensuing discussion of surface water development works described in this chapter, the following terms are used as indicated:

Safe Yield—The maximum sustained rate of draft from water development works that could have been maintained through a critically deficient water supply period to meet a given demand for water.

Irrigation Yield—The maximum sustained rate of draft from water development works that could have been maintained through a critically deficient water supply period to meet a given irrigation demand for water with certain specified deficiencies.

New Yield—That portion of the safe yield or irrigation yield resulting from a proposed new water supply development and method of operation thereof, over and above the yield of existing works.

Dependable Power Capacity—The minimum kilowatt capacity of the hydroelectric generating equipment when meeting an assumed load requirement. In this bulletin the load requirement was assumed to have the characteristic of 5,550 kilowatt-hours per kilowatt of annual peak demand, approximately representative of the present northern California power market.

Installed Power Capacity—The kilowatt name plate rating of the hydroelectric generating equipment. In this bulletin, the installed power capacity was determined as the optimum capacity which would develop the available water supply, and was taken as the capacity necessary to utilize twice the safe yield, equivalent to a minimum plant factor of 0.5.

Average Energy Output—The energy in kilowatt-hours generated by the hydroelectric generating equipment, with the available water supply, that would be usable under the assumed system load. For purposes of this bulletin, all of the energy output was assumed to be usable.

THE CALIFORNIA WATER PLAN

The Feather River Project, an adopted feature of The California Water Plan, is described in the following section, where it is shown that it could provide supplemental water to meet the probable ultimate requirements of the San Joaquin Area. Several other major projects, which would involve multipurpose water resources developments on the American, Cosumnes, Mokelumne, Calaveras and Stanislaus Rivers, could also provide supplemental water to meet the probable ultimate requirements of the area, and are briefly described in an ensuing section. These projects are tentatively being considered as possible features of The California Water Plan.

Feather River Project

The probable ultimate supplemental water requirement of the San Joaquin Area could be met under a plan which would provide regulatory storage on the Feather River, by construction of Oroville Dam and Reservoir near Oroville. A portion of the regulated water supply so made available could be conveyed across the Sacramento-San Joaquin Delta to the South Fork of the Mokelumne River and delta channels tributary thereto. The project water made available in these delta channels could be pumped to and distributed in the San Joaquin Area, lying immediately to the east.

A large number of samples of water have been taken from the delta channels over a period of years and analyzed for mineral constituents. The analyses indicate that the water was of good mineral quality and well suited for domestic and agricultural uses.

Oroville Dam and Reservoir, locations of which are shown on Plate 14, will be made available by construction of works which are described in detail in a publication of the State Water Resources Board, entitled "Report on Feasibility of Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of The California Water Plan," dated May, 1951, and a publication of the Division of Water Resources entitled "Program For Financing and Constructing The Feather River Project as the Initial Unit of The California Water Plan," dated February, 1955. These projects were authorized and adopted by the 1951 Legislature in an act which authorized their construction, operation, and maintenance by the Water Project Authority of the State of California. Provision was made in the authorizing act for financing construction of the proposed works through issuance and sale of revenue bonds and through receipt of contributions from other sources. In May, 1952, the Legislature provided $800,000 by budgetary appropriation to the Division of Water Resources, for necessary investigation, surveys, and studies and preparation of plans and specifications for the Feather River and Sacramento-San Joaquin Delta Diversion Projects. The 1953-54 Budget Act provides an additional $750,000 to the Division for like purposes.

The multipurpose Feather River Project contemplates construction of a concrete gravity dam, 730 feet in height above stream bed, at a point on the Feather River about 5.5 miles above the City of Oroville. It will create a reservoir of 3,500,000 acre-foot storage capacity, and will provide a large measure of control of the runoff of the Feather River for purposes of conservation, flood control, hydroelectric power generation, and other beneficial uses. Provision will be made for a power plant of 440,000 kilowatt installed power capacity located at the dam. Two afterbay dams will be located 0.5 mile upstream and five miles downstream from Oroville, respectively, to convert the power releases to a continuous flow. A channel crossing of the Sacramento-San Joaquin Delta will be required to carry water released from Oroville Reservoir from the Sacramento River to the San Joaquin River Delta, for subsequent transmission to water-deficient areas in more southerly parts of California.

Under the plan of operation of Oroville Reservoir described in the cited 1955 report, releases of water would be made sufficient to meet requirements of a service area along the Feather River under ultimate conditions of development. In addition, the releases would be sufficient to supplement other waters now available in the Sacramento-San Joaquin Delta so as to provide for existing rights and commitments including requirements of the Central Valley Project, and would make new water available for export from the Delta in the average amount of 4,016,000 acre-feet, annually.

Estimates of cost of the Feather River Project are presented in the 1955 report. A summary of estimated capital costs of this project, as it would relate to the San Joaquin Area, is given in Table 42. The estimates of capital cost were based on prices prevailing in January, 1955, and included allowances of 10 per cent for administration and engineering, 15 per cent for contingencies, and $2\frac{1}{2}$ per cent for interest during one-half of the estimated construction period.

TABLE 42

SUMMARY OF ESTIMATED CAPITAL COSTS OF FEATHER RIVER PROJECT

Oroville Dam and Reservoir	$279,586,000
Oroville Power Plant	27,926,000
Afterbays No. 1 and No. 2	6,027,000
Delta Cross-Channel	8,320,000
Subtotal	$321,859,000
Contingencies	34,111,000
Engineering and administration	31,083,000
Interest during construction	42,008,000
TOTAL	$429,061,000

Based on the foregoing estimated capital costs and other studies, it was estimated that cost of water from the Feather River Project, available for export from the Sacramento-San Joaquin Delta to the San Joaquin Area, would be about $2.50 per acre-foot at points of diversion in the Delta.

Folsom Project

The probable ultimate supplemental water requirement of the San Joaquin Area could be met under a plan which will provide regulatory storage on the American River, by construction of Folsom Dam and Reservoir, about $2\frac{1}{2}$ miles upstream from the town of Folsom and about one-half mile below the confluence of the North and South Forks of the river. A portion of the regulated water supply so made available could be conveyed to the San Joaquin Area by gravity conduit, or could be released to the Sacramento-San Joaquin Delta for pumped diversion to the San Joaquin Area, as described in the preceding section in the case of Feather River water.

Folsom Dam and Reservoir, locations of which are shown on Plate 14, are under construction and nearing completion by the Corps of Engineers, Department of the Army. Folsom Dam and Reservoir were authorized for federal construction in Public Law 534, 78th Congress, 2nd session, and were adopted and authorized by the State of California in Chapter 1514, California Statutes of 1945. Subsequently, the Folsom Project was authorized as a unit of the Central Valley Project by the Congress in Public Law 356, 81st Congress, 1st session. This authorization included Folsom Dam and Reservoir, Folsom Power Plant located below Folsom Dam, Nimbus Dam and Power Plant located about seven miles below Folsom Dam, and the Sly Park Project located in El Dorado County to furnish supplemental water to lands in and adjacent to the El Dorado Irrigation District. Under the legislation the power features and the Sly Park Project are being constructed by the Bureau of Reclamation, Department of the Interior. In addition to the presently authorized development, the Folsom Project contemplates eventual construction of conveyance and distribution systems for the conserved water, which features were not included in the foregoing legislation.

Yield studies presented in a report prepared by the Division of Water Resources pursuant to Senate Concurrent Resolution No. 48, Legislature of 1951, entitled "Feasibility of State Ownership and Operation of the Central Valley Project of California," dated March, 1952, indicate that new seasonal yield of Folsom Reservoir will be about 800,000 acre-feet. This report assumed that the yield of Folsom Reservoir would be used primarily in a service area extending along the east side of the Central Valley from Markham Ravine on the north to Littlejohns Creek on the south, and including the major portion of the San Joaquin Area. In order that this water might be utilized in the service area, it would be necessary to construct canals to convey releases from Folsom Reservoir both to the north and south of the American River.

The main section of Folsom Dam consists of a concrete gravity structure across the river channel, with a crest length of 1,400 feet and a height of 280 feet above stream bed. The left and right wings of the main dam, as well as several auxiliary dams, consist of earth-filled sections. The overpour spillway is located at the center of the concrete section of the main dam, and has a discharging capacity of 567,000 second-feet. The storage capacity of Folsom Reservoir is 1,000,000 acre-feet, and the reservoir area is 11,650 acres.

The Folsom Power Plant is located below Folsom Dam. The installed power capacity of the plant will be 162,000 kilowatts when completed, and the maximum head will be 340 feet. Nimbus Dam is located about seven miles below Folsom Dam, and the reservoir it creates, recently named Lake Natoma, will serve as an afterbay to re-regulate the power releases from the Folsom Power Plant to a uniform flow. The dam is a concrete structure with a crest length of 1,170 feet and a height of 45 feet above stream bed, and creates a reservoir with storage capacity of 7,700 acre-feet. The Nimbus Power Plant, located at the dam, will have an installed power capacity of 13,500 kilowatts when completed.

A summary of estimated capital costs of Folsom Dam and Reservoir, and appurtenant features, as furnished by the Bureau of Reclamation and the Corps of Engineers, is presented in the following tabulation:

Folsom Dam and Reservoir	$65,335,000
Folsom power facilities including Nimbus Afterbay Dam and Power Plant	38,201,000
TOTAL	$103,536,000

The Bureau of Reclamation is presently conducting detailed studies of the alignment and costs of the Folsom South Canal and of the areas which could be served from the canal. Preliminary data and information furnished by the Bureau of Reclamation indicate that water would be diverted into the Folsom South Canal from the American River at Nimbus Dam. The Folsom South Canal would extend southerly to Littlejohns Creek, a distance of approximately 50 miles. As presently planned, the Folsom South Canal would divert water from the American River at an elevation of about 118 feet and extend southerly, crossing the Cosumnes River at an elevation of about 110 feet, Dry Creek at an elevation of 100 feet, the Mokelumne River at an elevation of 95 feet, the Mokelumne Aqueduct of the East Bay Municipal Utility District at an elevation of about 93 feet, the Calaveras River at an elevation of about 90 feet, and end at Littlejohns Creek at an elevation of about 86 feet. Studies made by the Division of Water Resources indicate that it would probably be desirable to convey the water by gravity in the Folsom South Canal easterly and north of the Calaveras River a distance of about 3.5 miles to an elevation of about 89 feet. At this point the water would then be lifted to an elevation of 132 feet, and conveyed easterly by gravity, crossing the Calaveras River by means of a siphon immediately above Bellota with the water surface at an elevation of about 130 feet. The water would then be conveyed in a southerly direction, skirting the foothills south of Bellota, to Littlejohns Creek. The canal would terminate about two miles upstream from the town of Farmington at an elevation of about 124 feet. This alignment would eliminate the necessity of acquiring expensive rights of way south of the Calaveras River and, furthermore, would facilitate delivery of water to a larger service area than if the canal continued by gravity from the Calaveras River to Littlejohns Creek. The location of the described Folsom South Canal is shown on Plate 14. Water released from Folsom Reservoir and conveyed in the Folsom South Canal could serve a large portion of the San Joaquin Area by gravity.

In the cited report of the Division of Water Resources on feasibility of state ownership and operation of the Central Valley Project, it was assumed that water released from Folsom Reservoir would be delivered at the intake to the Folsom South Canal for $1.00 per acre-foot. This assumed rate of revenue from the sale of new seasonal yield from Folsom Reservoir was used in the financial analyses of the Central Valley Project presented in that report. Since the Bureau of Reclamation is presently conducting detailed studies of the alignment and costs of the Folsom South Canal, and probably will make such information available in the near future, no detailed studies for the Folsom South Canal were made by the Division of Water Resources. However, preliminary estimates of costs made by the Division, based on a preliminary alignment furnished by the Bureau of Reclamation to the Calaveras River, and the alignment contemplated by the Division of Water Resources from the Calaveras River to Littlejohns Creek, indicate that capital costs to deliver 609,000 acre-feet of water seasonally to Sacramento and San Joaquin Counties through the Folsom South Canal would be about $24,650,000. The estimated 609,000 acre-feet of water per season corresponds to the probable ultimate supplemental water requirement of lands which could be practicably served from the Folsom South Canal, including 303,000 acre-feet in San Joaquin County, based on studies made by the Division of Water Resources, and 306,000 acre-feet in Sacramento County, based on preliminary studies made by the United States Bureau of Reclamation. Annual costs on a 3 per cent and 4 per cent interest basis were estimated to be $1,306,000 and $1,517,000, respectively. Unit annual costs on a comparable basis, and including the assumed value of $1.00 per acre-foot for water delivered to the intake of the Folsom South Canal, were estimated to be $3.20 per acre-foot and $3.50 per acre-foot, respectively.

As has been mentioned, as an alternative to its conveyance in the Folsom South Canal, a portion of the yield of Folsom Reservoir could be released down the American and Sacramento Rivers to the Sacramento-San Joaquin Delta. It could then be conveyed across the Delta in a cross canal, and to the South Fork of the Mokelumne River and the delta channels tributary thereto. From the delta channels the water could be pumped to and distributed in the San Joaquin Area lying immediately to the east. Preliminary designs and cost estimates for such a conveyance system have not been made. However, based on data and estimates at hand, it is indicated that unit cost of the new seasonal yield from the Folsom Project would be little different than at Nimbus Dam, or about $1.00 per acre-foot at points of diversion in the Delta.

The Division of Water Resources, under the direction of the State Water Resources Board, has recently completed its investigation of the American River Basin, as authorized by Chapters 908 and 1541, Statutes of 1947, and subsequent regular budgetary appropriations, and has prepared the preliminary draft of State Water Resources Board Bulletin No. 21, entitled "American River Basin Investigation—Report on Development Proposed for The California Water Plan," covering the investigation. This report is conceived as the first of a series of individual stream basin and stream group reports designed to improve and refine the detail of The California Water Plan beyond the scope possible in the report thereon, to be published as State Water Resources Board Bulletin No. 3 in 1956.

Bulletin No. 21 presents a multipurpose plan which can serve as a guide for future basin development above Folsom Reservoir. It also illustrates how a high degree of conservation can be realized at comparatively low cost by utilizing, to full advantage, the valuable natural storage available in the alluvium of the valley floor below Folsom Reservoir.

The area under investigation reported in Bulletin No. 21 comprises the areas of origin and use of American River water. This includes the entire American River watershed, portions of adjoining watersheds in which use is made of water originating or stored in the American River Basin, and the valley floor service area dependent wholly or in part on the American River as a source of water supply.

In the preliminary draft of Bulletin No. 21 it was assumed that, for study purposes, the valley floor service area of the American River would occupy an area bounded roughly by the Sierra foothill line on the east and the trough of the Sacramento-San Joaquin Valley on the west. The northerly boundary would be in the vicinity of the American River, and the area would extend southward to Lone Tree Creek south of Stockton.

With full development of the American River Basin, and when full conjunctive use of ground water storage in the valley is achieved, the water from the American River would irrigate nearly 800,000 acres of land in the uplands and on the valley floor; meet the domestic, urban, and industrial water requirements for a population in excess of 1,400,000; maintain a flow of about 600 second-feet in the American River below Nimbus; provide a firm seasonal supply of about 368,000 acre-feet of water for export to deficient areas; and, by use of residual outflow from irrigation applications, urban uses, and pumping for salt balance, provide the river's proportionate share of water required to repulse sea-water intrusion at the Delta.

The works required to achieve the high degree of water resource development envisioned for the American River Basin fall into two broad categories. The first constitutes works located in the basin itself, including facilities to supply water to foothill and mountain service areas beyond the boundaries of the basin. The second category constitutes works on the valley floor, including those required to implement conjunctive operation of surface and underground storage. In the proposed ultimate plan, 22 reservoirs would store and regulate a substantial portion of the basin runoff, and the regulated water would flow to 5 foothill and mountain service areas, and to 19 hydroelectric power plants, through nearly 300 miles of conduit. On the valley floor the water would be conveyed into the service area by 150 miles of main canal, where it would be distributed by laterals and other works, in conjunction with drainage and deep well pumping facilities, to achieve maximum beneficial use of the water.

The total capital cost of these new works was estimated to be about $418,000,000 at present prices. The corresponding annual cost on a 3 percent interest basis was estimated to be about $25,500,000. It was estimated that after the capital costs are recovered, the annual costs would be reduced to about $10,725,000. The estimates of annual costs are subject to reduction in the amount of the hydroelectric power revenues that might be assigned for payment of irrigation features of the project. Annual power revenues, based on unit values of $22 per kilowatt of new dependable power capacity and 2.8 mills per kilowatt-hour of new energy output, would amount to about $17,300,000. Therefore, estimated average unit cost of the new water supply of 2,174,000 acre-feet at points of delivery, including re-use of firm supplies in downstream areas, and crediting the annual costs of new works with power revenues, would be about $3.80 per acre-foot during the amortization period. After project repayment power revenues alone would exceed annual costs.

Other Projects Under Consideration

In connection with the State-wide Water Resources Investigation and the Survey of Mountainous Areas, various plans for development of the water resources of Sierra Nevada streams are under consideration. Among the streams under investigation, in addition to the Feather and American Rivers already discussed in part, are the Cosumnes, Mokelumne, Calaveras, and Stanislaus Rivers, and Dry Creek. All five of these latter streams were considered as possible sources of additional water supply for the San Joaquin Area, as well as for the foothill and mountain water service areas of the streams. These service areas are located to the east of the San Joaquin Area, and are shown on Plate 16, "Potential Water Developments." With the exception of small portions of some of the lower foothill service areas, none can be practicably supplied with water directly from the Central Valley Project, the Feather River Project, or from possible large, low-elevation reservoirs on the five cited tributary streams. Probable ultimate water requirements of the mountain and foothill areas are substantial, and very little water has been developed for use in those areas to date. On the other hand, the waters of the Stanislaus and Mokelumne Rivers, by far the larger of the five streams, have been developed to a considerable degree for the benefit of areas on the Central Valley floor and in the San Francisco Bay Area.

Since the foregoing studies and investigations are in progress, no final conclusions regarding project plans and costs, and allocations of new safe yields, can be made at this time. The investigations are sufficiently advanced, however, to permit conclusions regarding ultimate water requirements, tentative conclusions regarding potential water supplies, and generalized descriptions of possible projects. Future development and use of water in the foothill and mountain service areas will affect the development of supplemental water supplies for the San Joaquin Area. In order to establish the nature and extent of such effects, a general discussion of potential yields of the various streams, ultimate water requirements in the foothill and mountain water service areas, and possible plans for water resource development is presented separately for the Cosumnes River, Dry Creek, and the Mokelumne, Calaveras, and Stanislaus Rivers. Because of present lack of preliminary designs and cost estimates, the discussion does not include consideration of economic or financial feasibility of possible water development works.

The quantity of water which must be delivered to a given service area to satisfy ultimate consumptive use of applied water may be considered as the ultimate water requirement of the service area. This requirement may be computed by adjusting the estimate of ultimate consumptive use of applied water for estimated conveyance and application losses within the service area. In the foothill and mountain service areas the requirement will be satisfied principally by water released from reservoirs. However, a part of the requirement may be satisfied by recoverable return flows originating within the area itself, and another part may be satisfied by return flow from upstream service areas. As a first step in deriving such requirements, it may be assumed that, under conditions of ultimate development, the cost of water and the available supply of water will be such that conveyance and application losses will have to be reduced to a minimum, and that every effort will have to be made to recover return flows. On this basis, it was considered reasonable to assume that average irrigation efficiencies of 75 per cent could be accomplished; that conveyance losses within the service area could be restricted to a quantity equivalent to 10 per cent of consumptive use of applied water; and that return flow could be recovered in quantities sufficient to balance the conveyance loss. Under these conditions, the service area requirement would be equivalent to consumptive use of applied water plus 33 per cent. Service area requirements, computed on this basis, are presented in subsequent sections covering the Cosumnes River, Dry Creek, and the Mokelumne, Calaveras, and Stanislaus Rivers.

Cosumnes River. The mean seasonal runoff of the Cosumnes River at the gaging station at Michigan Bar is estimated to be about 374,000 acre-feet. Reservoir yield studies indicate that under conditions of maximum practicable development, the stream could produce a dependable water supply of about 200,000 acre-feet per season. Under present conditions the stream is virtually undeveloped for beneficial use of water. There are a few diversions from the stream, but the total quantity of water diverted is small and most of the runoff is wasted into the Sacramento-San Joaquin Delta. The only new development scheduled for completion in the near future is the previously cited Sly Park Project of the Bureau of Reclamation, which will yield about 20,000 acre-feet of water per season from tributaries of the North Fork of the Cosumnes River, to supplement waters of the American River presently used in the service area of the El Dorado Irrigation District.

The mountain and foothill water service areas for which the Cosumnes River is considered to be a natural source of water supply are listed in the following tabulation, together with their estimated ultimate seasonal water requirements. The water requirements are measured in terms of consumptive use of applied water plus irrecoverable losses incidental to such use.

Service Area	*County*	*Estimated ultimate mean seasonal water requirements, in acre-feet*
Ione	Amador	77,000
Plymouth	Amador	20,000
Volcano	Amador	17,000
Aukum	El Dorado	19,000
Latrobe	El Dorado	12,000
Placerville	El Dorado	96,000
Youngs	El Dorado	12,000
Carson	Sacramento	75,000
Laguna	Sacramento	94,000
Arroyo Seco	San Joaquin	35,000
TOTAL		457,000

Obviously, draft on the Cosumnes River to meet the foregoing requirements would far exceed the maximum water supply which can be developed from the stream. Plans for development currently under consideration, therefore, contemplate the use of Cosumnes River water in those service areas for which there is no reasonable alternative source, and the development of water from the South Fork of the American River to make up the deficiency in other service areas. Runoff of local streams, such as Dry Creek in Amador County, would also be developed and utilized so far as practicable.

Briefly, it is contemplated that the Plymouth, Volcano, Aukum, and Youngs Service Areas would be supplied with sufficient water substantially to meet their ultimate requirements from the Cosumnes River, through the construction of Bridgeport, Pi Pi Meadows, and Capps Crossing Reservoirs in the upper part of the basin. The Sly Park Project will meet a part of the ultimate water requirement of the Placerville Service Area, and the remainder could be met by water developed from the South Fork of the American River and conveyed to Sly Park Reservoir largely by gravity conduit. A description of a comprehensive plan of water resources development of the American River, including the foregoing diversion to Sly Park Reservoir, is included in Bulletin No. 21, entitled "American River Basin Investigation—Report on Development Proposed for The California Water Plan," a publication of the State Water Resources Board.

Some water could be diverted directly from Folsom Reservoir by gravity and conveyed by conduit for use in the Carson Service Area. Construction of Deer Creek Reservoir on Deer Creek would also produce a limited quantity of water for this service area. The remainder of the ultimate water requirement in the Carson Service Area, and all of the requirement in the Latrobe Service Area could be satisfied with water from the South Fork of the American River, through an extension of the conveyance and distribution system serving the Placerville Service Area.

The remaining flow of the Cosumnes River could be regulated in the proposed Nashville Reservoir, located on the main stream about one-half mile below the junction of the North and Middle Forks. However, since the amount of the remaining yield of water in the Cosumnes River would not be sufficient to satisfy the probable ultimate requirements of the Laguna, Ione, and Arroyo Seco Service Areas, it would be necessary to augment natural inflow to Nashville Reservoir by importing surplus water from the South Fork of the American River. This import could be released through Sly Park Reservoir. A canal would convey water from Nashville Reservoir into Amador County, for distribution by gravity to points of use in the Ione, Laguna, and Arroyo Seco Service Areas.

On the basis of the foregoing discussion, it is indicated that the potential water supply available in the Cosumnes River is inadequate to satisfy probable ultimate water requirements in the mountain and foothill service areas for which it is a natural source of supply. However, sufficient supplemental water could be imported from the South Fork of the American River to augment the local supplies and meet the ultimate requirements. Under such a plan of water development and utilization, little or no potential yield would remain for development in the Cosumnes River for possible utilization in the San Joaquin Area.

Dry Creek. The mean seasonal runoff of Dry Creek at the old gaging station near Ione is estimated to be about 100,000 acre-feet. Reservoir yield studies indicate that the dependable water supply which could be practicably developed from the stream is about 45,000 acre-feet per season. Dry Creek is considered to be a natural source of water supply for the previously described Ione, Laguna, and Arroyo Seco Service Areas, and for the Jackson Service Area in Amador County as well. The probable ultimate mean seasonal water requirement of the Jackson Service Area is estimated to be about 22,000 acre-feet.

The runoff of Dry Creek probably could be controlled most practicably by construction of a dam and reservoir at the Ione site, located on the main stream about one mile west of the Amador county boundary. Potential storage capacity at this site, with a dam 150 feet in height, exceeds 1,000,000 acre-feet, far more than would be necessary to control the runoff of Dry Creek. However, it would be possible to store spill from the proposed Nashville Reservoir on the Cosumnes River in Ione Reservoir, and surplus water from the Mokelumne River could be diverted to Ione by means of the Jackson Creek spillway of the existing Pardee Reservoir. In this way, storage capacity required for flood control on the Mokelumne River could be transferred to Ione Reservoir. Stream bed elevation at the Ione dam site is only about 160 feet. For this reason, water from Ione Reservoir could be delivered by gravity only to the extreme westerly portions of the Laguna and Arroyo Seco Service Areas, and to the northern part of the San Joaquin Area.

Possible upstream development on Dry Creek consists of a dam and reservoir at the Irish Hill site, on Dry Creek about 3.5 miles due north of Ione, with a diversion from Sutter Creek to the Irish Hill site. The Irish Hill Reservoir could serve as a regulator for diversions from the proposed Nashville Reservoir on the Cosumnes River, and could develop the natural runoff of Dry Creek for use in the Ione Service Area.

On the basis of the foregoing discussion, it is indicated that the potential water supply available in Dry Creek is inadequate to satisfy probable ultimate water requirements in the mountain and foothill service areas for which it is a natural source of supply. Furthermore, the probable ultimate water requirements of the Ione, Laguna, and Arroyo Seco Service Areas could be most practicably satisfied by water developed from the Cosumnes and American Rivers, as described in the preceding section. The probable ultimate water requirement of the Jackson Service Area could be met by water developed on Sutter Creek, augmented by imports of water from the Mokelumne River through the Amador Canal. Under such a plan of water development and utilization, a moderate amount of potential yield would remain for development in Dry Creek for possible utilization in the San Joaquin Area.

Mokelumne River. The mean seasonal runoff of the Mokelumne River near Clements is estimated to be about 780,000 acre-feet. Reservoir yield studies indicate that the maximum practicable development of the stream would produce a dependable seasonal water supply of about 550,000 acre-feet, or slightly more than 70 per cent of the mean seasonal runoff. The Mokelumne River is now subject to heavy drafts of water for irrigation, municipal, and hydroelectric power purposes. Measured and estimated seasonal diversions of water from the Mokelumne River from 1948-49 through 1951-52 are shown in the following tabulation.

	Quantity, in acre-feet			
Diversions by	*1948-49*	*1949-50*	*1950-51*	*1951-52*
East Bay Municipal Utility District	128,000	114,000	93,800	102,800
Woodbridge Irrigation District	132,200	147,700	118,000	124,900
Riparian and appropriative divertors below Pardee Reservoir *	14,600	14,600	14,600	14,600
Releases from Pardee Reservoir for ground water storage, and channel losses *	24,300	24,300	24,300	24,300
Pacific Gas and Electric Company, Amador Canal	6,400	7,000	6,200	5,600
Calaveras Public Utility District	5,200	5,700	5,800	6,300
TOTALS	309,700	312,300	261,700	277,500

* Estimates obtained from East Bay Municipal Utility District.

Studies conducted to determine the safe seasonal yield of water from existing works on the Mokelumne River indicate that about 405,000 acre-feet could be developed by such works. A summary of the yield study for existing works, less the seasonal entitlement of 24,000 acre-feet of water required by Pacific Gas and Electric Company for its Amador Canal and the Calaveras Public Utility District, is presented in Appendix J. The present entitlement of the East Bay Municipal Utility District to divert water from the Mokelumne River provides for a continuous diversion of 310 second-feet, equivalent to about 224,000 acre-feet per season. Had the utility district diverted the full amount of its right in 1949-50, and had other diversions remained the same as for that season, the shortage in developed supply would have amounted to about 17,000 acre-feet.

The development of new water supplies for municipal purposes from the Mokelumne River is under consideration by the East Bay Municipal Utility District. Tentative plans call for the construction of three new dams and reservoirs, as follows:

Reservoir	*Stream*	*Gross storage capacity, in acre-feet*
Middle Bar	Main stream	46,500
Railroad Flat	South Fork	80,000
Camanche	Main stream	212,000

In addition, the storage capacity of Pardee Reservoir would be increased by about 17,000 acre-feet through the installation of spillway gates at Pardee Dam. In connection with these plans, the district has filed an application with the Division of Water Resources to appropriate water, providing for an additional diversion of 140,000 acre-feet each season, over and above the amount of its present right.

The Mokelumne River is considered to be a natural source of supply for certain mountain and foothill water service areas in Calaveras, Amador, and San Joaquin Counties. Although it would be physically possible to deliver water from the Mokelumne River to the Volcano, Ione, and Arroyo Seco Service Areas, preliminary studies indicate that it would probably be more feasible to serve these areas as heretofore described. As mentioned in the preceding section, the Jackson Service Area could utilize the supply made available by the Amador Canal and by development of Sutter Creek. Those mountain and foothill service areas in Calaveras and San Joaquin Counties which most practicably could be supplied with water from the Mokelumne River are listed in the following tabulation.

Service Area	*County*	*Estimated ultimate mean seasonal water requirements, in acre-feet*
West Point	Calaveras	6,000
Mokelumne	Calaveras	31,000
Bear Creek	San Joaquin	75,000
TOTAL		112,000

The Mokelumne River is considered to be the most practicable source of water supply for the West Point Service Area. Construction of Bear Creek Dam and Reservoir on Bear Creek, a tributary of the Middle Fork of the Mokelumne River, with natural inflow augmented by a diversion from Forest Creek, would satisfy the probable ultimate requirements of the service area.

Water for the Mokelumne Service Area could be developed from the South and Middle Forks of the Mokelumne River. For this purpose, a dam and reservoir could be constructed at the Railroad Flat site on the South Fork, and delivery of water from this source to the service area could be accomplished by enlarging and extending the existing Mokelumne Hill Ditch of the Calaveras Public Utility District. Inflow to Railroad Flat Reservoir could be augmented by releases of stored water from the existing Schaad Reservoir on the Middle Fork of the Mokelumne River, plus downstream diversion of unregulated flows from the Middle Fork through the existing ditch of the Calaveras Public Utility District, which would be enlarged for this purpose. The proposed Railroad Flat Reservoir could not serve all lands in the Mokelumne Service Area by gravity. However, those lands situated above the elevation of the reservoir outlet could be served by a smaller reservoir that would be created by construction of a dam at the McCarty site on the North Fork of the Calaveras River. The natural inflow at the McCarty site is small, but additional water could be brought from the South Fork of the Mokelumne River for regulation in McCarty Reservoir, augmented by water from the North Fork of the Stanislaus River, the diversion being accomplished by enlargement of the Old Clark Ditch.

The Bear Creek Service Area could be supplied by a pump lift of water from the proposed Camanche Reservoir, below Pardee Reservoir on the Mokelumne River, to satisfy its probable ultimate requirement. The Mokelumne River, however, is not the only practicable source of water supply for the Bear Creek Service Area. Water could be delivered to this area, in an amount sufficient to meet only a portion of its probable ultimate requirement, from the proposed New Hogan Reservoir on the Calaveras River. This possibility is described in more detail in subsequent discussion of the Calaveras River. It also could be supplied by a pump lift of water from the American River carried in the proposed Folsom South Canal. One or more of these alternatives could provide sufficient water to meet probable ultimate requirements of the Bear Creek Service Area.

On the basis of the foregoing discussion, it is indicated that the potential undeveloped water supply available in the Mokelumne River could satisfy the estimated ultimate water requirements of mountain and foothill service areas for which it is a natural source of supply. However, under such development and utilization of the water, little or no new water would remain for the San Joaquin Area, or for export to the San Francisco Bay Area, and adjustments would probably be required with present downstream users of Mokelumne River water.

Calaveras River. The mean seasonal runoff of the Calaveras River at Jenny Lind is estimated to be about 199,000 acre-feet. Reservoir yield studies indicate that the safe seasonal yield of the stream, under conditions of maximum practicable storage development, would be about 100,000 acre-feet. Present use of water from the Calaveras River in the upper basin above Bellota is small. However, diversions downstream from Bellota have increased substantially in recent years, through utilization of the limited conservation storage capacity available in Hogan Reservoir.

The Calaveras River is considered to be a natural source of water supply for certain mountain and foothill water service areas in Calaveras County. Unfortunately, however, there is little opportunity to develop an appreciable water supply above Hogan Reservoir, because the river heads from eight branches in the upper basin and the runoff in each is small.

The possibility of constructing a dam and reservoir on the North Fork of the Calaveras River at the McCarty site for the benefit of the Mokelumne Service Area in Calaveras County has been mentioned previously. The major part of the inflow to this reservoir would come from the South Fork of the Mokelumne River, and the yield developed from flow of the Calaveras River would be small.

The only other development of the Calaveras River above Hogan Reservoir under consideration at present would involve the construction of a dam and reservoir on San Domingo Creek about two miles northwest of Murphys. Inflow to the San Domingo Reservoir could be increased by a diversion and conduit from San Antonio Creek. The water supply developed could be used to satisfy a part of the ultimate water requirement in the Stanislaus and Bear Mountain Service Areas, estimated to be about 64,000 acre-feet per season. The remainder of the water required for these areas would have to be imported from the Stanislaus River. Tentative plans for development of the Stanislaus River for the benefit of service areas in Calaveras County are described in subsequent discussion.

On the basis of studies completed to date, it appears that the most feasible way to develop the Calaveras River would be through construction of the proposed New Hogan Reservoir, which has already been authorized as a federal project to be constructed by the Corps of Engineers, United States Army. Funds have not been authorized for its construction to date. Water from New Hogan Reservoir could be delivered to the Bear Creek Service Area, as previously mentioned, and to the Hogan Service Area, which has an estimated ultimate seasonal requirement for water of about 48,000 acre-feet. Virtually all of the new yield produced by New Hogan Reservoir could be used in the Hogan Service Area.

On the basis of the foregoing discussion, it is indicated that the potential new water supply which could be practicably developed from the Calaveras River is inadequate to supply probable ultimate water requirements in the mountain and foothill service areas for which it is a natural source of supply. However, sufficient supplemental water probably could be imported from the Stanislaus River to augment the local supply

Hogan Dam on Calaveras River

and meet the ultimate requirements. Under such a plan of water development and utilization, little or no potential yield would remain for development in the Calaveras River for possible utilization in the San Joaquin Area.

Stanislaus River. The mean seasonal runoff of the Stanislaus River at Knights Ferry is estimated to be about 1,210,000 acre-feet. Reservoir yield studies indicate that the seasonal yield of the stream, under conditions of maximum practicable storage development, would be about 840,000 acre-feet. It is estimated that almost 50 per cent of this potential yield is developed by existing reservoirs on the river. The principal water users are the Oakdale and South San Joaquin Irrigation Districts. In 1950-51 these districts diverted about 424,000 acre-feet of water from the Stanislaus River for the irrigation of about 121,000 acres of land. The only diversions of significance in the upper basin are made through the Utica and Tuolumne Canals of the Pacific Gas and Electric Company. The Utica Canal conveys water from the North Fork of the Stanislaus River into Calaveras County for irrigation, domestic, and hydroelectric power purposes. However, most of the water diverted returns to the Stanislaus River after delivery through the Angels Power House, and it is estimated that less than 5,000 acre-feet per season are consumptively used in Calaveras County. The Tuolumne Canal diverts water from the South Fork of the Stanislaus River for irrigation, domestic, and hydroelectric power purposes in Tuolumne County. None of the water so diverted returns to the Stanislaus River.

The Oakdale and South San Joaquin Irrigation Districts have estimated their probable ultimate gross diversion requirement from the Stanislaus River to be about 511,000 acre-feet per season, considerably more water than the existing storage system will develop on a dependable basis. In order to assure the availability of a dependable water supply in this amount, the districts are initiating the construction of dams and reservoirs at the Donnells and Beardsley sites on the Middle Fork of the Stanislaus River. Construction of a dam and reservoir at the Tulloch site on the main stream below Melones Reservoir is proposed later by the districts. Releases from the new Donnells Reservoir will be conveyed through a tunnel to the proposed Donnells Power Plant, and thence to the new Beardsley Reservoir. Power plants will also be constructed below Beardsley and Tulloch Reservoirs. The water rights necessary for this so-called "Tri-Dam Project" are covered by permits recently issued to the districts by the Division of Water Resources. The additional storage capacity provided by the project should assure a dependable water supply sufficient to satisfy the ultimate requirements of the districts.

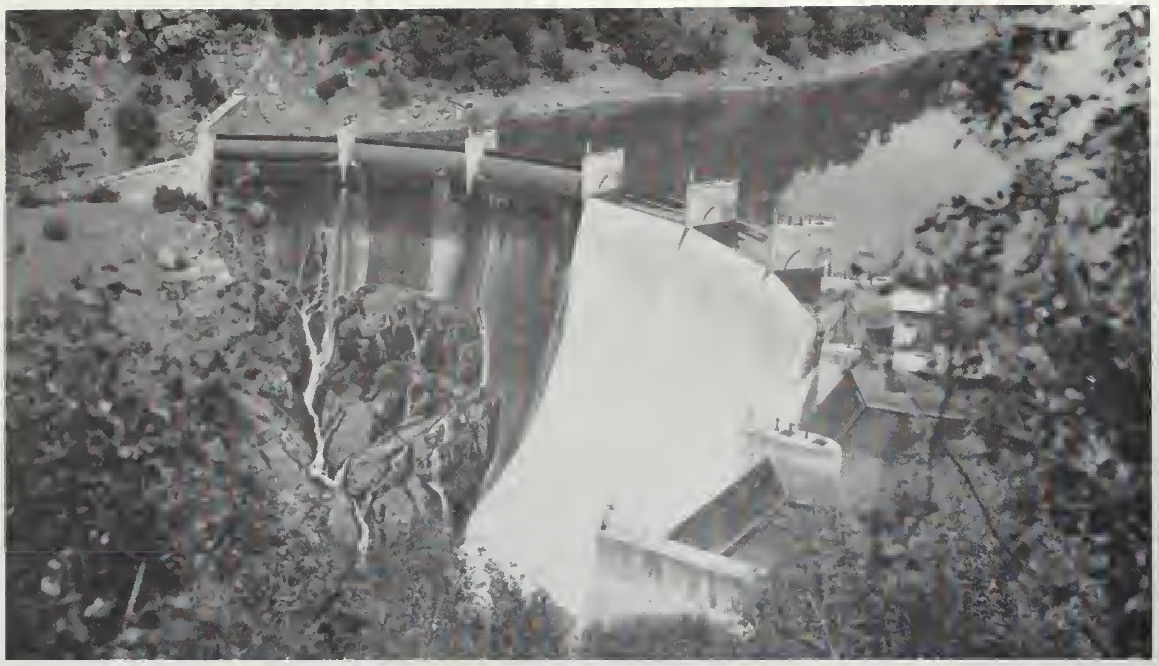
The Stanislaus River is considered to be a natural source of water supply for certain mountain and foothill service areas in Calaveras and Tuolumne Counties. Additional water could be developed from the North Fork of the Stanislaus River for delivery to service areas in Calaveras County, and from the South and Middle Forks for delivery to service areas in Tuolumne County. The projects under consideration for Calaveras County have no direct physical relation to those which would serve Tuolumne County.

Service areas in Calaveras County which could be practicably supplied with water from the North Fork of the Stanislaus River are listed in the following tabulation, together with their estimated ultimate water requirements. It should be noted that about 30 per cent of the Rock Creek Service Area is in Stanislaus County.

Service Area	*County*	*Estimated ultimate mean seasonal water requirements, in acre-feet*
Stanislaus	Calaveras	26,000
Calaveras	Calaveras	31,000
Bear Mountain	Calaveras	38,000
Rock Creek	Calaveras	12,000
TOTAL		107,000

Tentative plans for the development of additional water from the North Fork of the Stanislaus River for use in Calaveras County would involve the construction of dams and reservoirs at the Spicers Meadow site on Highland Creek, at the Ganns and Ramsey sites on the North Fork, at the Beaver Creek site on Beaver Creek, and at the Griswold site on Griswold Creek. Water could be diverted from Ganns and Ramsey Reservoirs and released into tributaries of the Calaveras River for rediversion to points of use in the Calaveras Service Area. Releases of water from all of the cited reservoirs could be diverted to points of use in the Stanislaus Service Area by means of the Utica Canal, which could be enlarged to handle the increased flow. Re-regulation of these inflows could be provided in the proposed San Domingo Reservoir on San Domingo Creek, and a new conduit could convey water from San Domingo Reservoir to the Bear Mountain and Rock Creek Service Areas. Plans for the development of hydroelectric power in conjunction with the proposed reservoirs are under consideration. Yield of the reservoirs would be sufficient to meet the probable ultimate water requirements of the Stanislaus, Calaveras, Bear Mountain, and Rock Creek Service Areas. However, operation of the reservoirs for this purpose would probably require substantial adjustment with present downstream users of Stanislaus River water.

As a result of an agreement executed in 1951 between the Oakdale and South San Joaquin Irrigation Districts and the Calaveras County Water District, the irrigation districts agreed that they would not object to the assignment by the State Depart-


Melones Dam on Stanislaus River, Spilling


Melones Dam on Stanislaus River, Nearly Empty

ment of Finance to the Calaveras County Water District of all its rights under that certain application to appropriate unappropriated water numbered 5648, insofar as that application pertains to water from the North Fork of the Stanislaus River and its tributaries. State Department of Finance Application No. 5648 provides for 65,000 acre-feet of storage capacity at Spicers Meadow, 30,000 acre-feet of storage capacity at Ramsey, and a diversion at the rate of 975 second-feet from the North Fork of the Stanislaus River.

The exercise of present rights on the North Fork of the Stanislaus River, with proper re-regulation of diversions, would yield about 50,000 acre-feet of water seasonally in Calaveras County. Further development of surplus waters in the North Fork by constructing 62,000 acre-feet of storage capacity at Spicers Meadow and 32,000 acre-feet at Ramsey would yield about 53,000 acre-feet of water per season, over and above the yield which can be obtained under present rights.

Service areas in Tuolumne County which could be practicably supplied with water from the South Fork of the Stanislaus River are listed in the following tabulation, together with their estimated ultimate water requirements. It is pointed out that a small part of the Keystone Service Area is in Stanislaus County.

Service Area	*County*	*Estimated ultimate mean seasonal water requirements, in acre-feet*
Lyons	Tuolumne	12,000
Phoenix	Tuolumne	36,000
Keystone	Tuolumne	24,000
TOTAL		72,000

Plans under consideration for the development of additional water from the South Fork of the Stanislaus River for use in Tuolumne County would involve the construction of a dam and reservoir at the Big dam site, located about six miles upstream from the existing Strawberry Reservoir, and enlargement of the existing Lyons Reservoir by construction of a new dam just downstream from the existing structure. The existing Tuolumne Canal could be enlarged to handle the increased diversions. The Lyons Service Area could be served directly from the Tuolumne Canal, and the remaining water could be re-regulated in an enlarged Phoenix Reservoir, on Sullivan Creek, for rediversion to points of use in the Phoenix and Keystone Service Areas.

As a result of an agreement executed in 1951 between the Oakdale and South San Joaquin Irrigation Districts and Tuolumne County Water District No. 2, the latter district may divert certain quantities of water from the Middle and South Forks of the Stanislaus River for conveyance to points of use in Tuolumne County. The agreement provides that Tuolumne County Water District No. 2 may divert Middle Fork water from the proposed Donnells Conduit of the Tri-Dam Project for conveyance to the South Fork of the Stanislaus River. The right to divert this water is limited to such times as Beardsley Reservoir is spilling, and the maximum allowable diversion is 600 acre-feet per day at a maximum rate of 600 second-feet. Any diversions of water accomplished under this agreement would be conveyed to the South Fork of the Stanislaus River by means of a new conduit, and would be re-diverted to points of use in the Lyons, Phoenix, and Keystone Service Areas by means of an enlarged Tuolumne Canal. The agreement provides that the water so diverted shall be under Application No. 5648 of the Department of Finance insofar as it relates to water of the Middle Fork of the Stanislaus River. With a diversion limited to 600 acre-feet per day, and with 65,000 acre-feet of regulatory storage capacity provided in Lyons Reservoir on the South Fork of the Stanislaus River, about 25,000 acre-feet of new water per season would be provided at Lyons Dam. The agreement also provides that the irrigation districts agree and consent to Department of Finance Application No. 5649 for appropriation of water, filed with the Department of Public Works, being assigned to Tuolumne County Water District No. 2, insofar as it relates to waters of the South Fork of the Stanislaus River. State Department of Finance Application No. 5649 provides for 59,000 acre-feet of storage capacity at three sites on the South Fork of the Stanislaus River, including the Lyons site, and direct diversion at the Lyons site at the rate of 600 second-feet. Conservation of surplus water in the South Fork of the Stanislaus River by construction of an enlarged Lyons Reservoir, with an additional storage capacity of 59,000 acre-feet, would provide a new irrigation yield of about 26,000 acre-feet seasonally.

Full utilization of the water of the South Fork of the Stanislaus River awarded in the Stanislaus River Decree for use through the Tuolumne Ditch System, and re-regulation of the releases of water from the Phoenix Power Plant in a reservoir of about 18,000 acre-foot storage capacity on Sullivan Creek, would yield about 30,000 acre-feet of water seasonally. Yield of water from the works described in this and the preceding paragraph would be sufficient to satisfy the probable ultimate requirements of the Lyons, Phoenix, and Keystone Service Areas.

The development of the Tri-Dam Project, and of any other of the described possible projects which might be constructed for the benefit of Calaveras and Tuolumne Counties, would result in a relatively high degree of regulation of the Stanislaus River. The most feasible possibility for further development probably would be the proposed New Melones Reservoir. The potential storage capacity of this reservoir, which would be formed by building a new dam a short distance downstream from the existing Melones Dam, is more than 1,000,000 acre-feet. Although the yield in new water would not be large in comparison to storage capacity of the reservoir, the project would provide substantial flood control benefits.

On the basis of the foregoing discussion, it is indicated that the potential undeveloped water supply available in the Stanislaus River could satisfy the estimated ultimate water requirements of mountain and foothill service areas for which it is a natural source of supply, if augmented by additional water developed on the Calaveras River. Under such a plan of development and utilization of the water, a moderate amount of potential yield would remain for development in the Stanislaus River for possible utilization in the San Joaquin Area. However, with such maximum upstream water use, adjustment would probably be required with present downstream users of the Stanislaus River water.

PLANS FOR INITIAL LOCAL DEVELOPMENT

Possible plans for initial local development of supplemental water supplies for the San Joaquin Area, together with cost estimates, are described in this section. Design of features of the plans was necessarily of a preliminary nature and primarily for cost estimating purposes. More detailed investigation, which would be required in order to prepare plans and specifications, might result in designs differing in detail from those presented in this bulletin. However, it is believed that such changes would not be signficant.

Capital costs of dams, reservoirs, diversion works, conduits, pumping plants, power plants, and appurtenances, included in the considered conservation, conveyance, and distribution systems, were estimated from preliminary designs based largely on data from surveys made during the current investigation. Approximate construction quantities were estimated from these preliminary designs. Unit prices of construction items were determined from recent bid data on projects similar to those in question and from manufacturers' cost lists, and are considered representative of prices prevailing in April, 1953. The estimates of capital cost include costs of rights of way and construction, and interest during one-half of the estimated construction period at both 3 and 4 per cent per annum, plus 10 per cent for engineering, and 15 per cent of construction costs for contingencies. Estimates of annual costs include interest on the capital investment at both 3 and 4 per cent, repayment over a 50-year period on both a 3 and 4 per cent sinking fund basis, replacement, operation and maintenance costs, and costs of electrical energy for pumping.

Twelve possible plans of works for initial construction which could provide supplemental water to the several units of the San Joaquin Area were considered, and are described in some detail in this section. For ready reference, the present and probable ultimate requirements for supplemental water in the San Joaquin Area are recapitulated in the following tabulation:

	Supplemental seasonal water requirement, in acre-feet	
	Present	*Probable ultimate*
Western Mokelumne Unit	0	34,000
Eastern Mokelumne Unit	28,500	126,800
Calaveras Unit	18,400	51,800
Littlejohns Unit	50,500	169,600
TOTALS	97,400	382,200

Delta-Mokelumne River Diversion Project

A satisfactory site for pumped diversion of surplus water from the Sacramento-San Joaquin Delta for the benefit of the Western and Eastern Mokelumne Units exists on a branch of Sycamore Slough, a tributary to the South Fork of the Mokelumne River. The site selected for cost estimating purposes is at a point about 6.5 miles due west of Woodbridge.

Water available in the Sacramento-San Joaquin Delta, over and above requirements of the Central Valley Project and other established rights and commitments, would be insufficient to meet requirements in the Western and Eastern Mokelumne Units in some months during the irrigation season of certain dry years. Such shortages would have occurred in 11 years during the 25-year period from 1927 through 1951. However, a firm water supply could be obtained in the Delta either from the Feather River or Folsom Projects.

Under this project, water diverted from the Delta would be conveyed in a canal due east to a point near Woodbridge, where it would be discharged into the existing conveyance and distribution system of the Woodbridge Irrigation District, for use in the service area of the district in the Western Mokelumne Unit. In exchange, an equal amount of water would be diverted from the Mokelumne River, one-half of which would be pumped from a point near Clements to serve irrigable lands lying south of the river, and the other half of which would be pumped from the river at a point near Lockeford to serve irrigable lands lying north of the river. The lands that would be so served lie in the Eastern Mokelumne Unit. This plan is hereinafter referred to as the "Delta-Mokelumne River Diversion Project," and its principal features are designated the "Delta Diversion," "Lockeford Diversion," and "Clements Diversion." The project is illustrated on Plate 17, entitled "Delta-Mokelumne River Diversion Project."

The Delta-Mokelumne River Diversion Project was designed to provide a seasonal diversion of 60,000 acre-feet of supplemental water, which would meet the present supplemental requirement of the Eastern Mokelumne Unit and would provide water for additional development of irrigable lands. An estimate of the monthly distribution of demand for a surface irrigation supply in the San Joaquin Area was presented in Table 39. Studies indicated that the maximum monthly diversion of water for the project would occur in July, and that it would amount to about 22 per cent of the total seasonal diversion of 60,000 acre-feet, equivalent to a continuous flow of about 213 second-feet throughout the month. The project was designed with a total capacity of 250 second-feet, which capacity would meet the estimated monthly maximum rate of demand, and provide additional capacity for shorter-term peaking in excess of the average monthly rate.

Based upon known soil characteristics in the Western and Eastern Mokelumne Units, it was assumed that losses in conveyance of water diverted from the Delta to the vicinity of Woodbridge would be negligible. However, it was estimated that losses in conveyance and distribution of the exchange water in the unlined canals of the Clements Diversion would be about 25 per cent of the gross diversion, leaving about 22,500 acre-feet per season for surface application to lands south of the river. Assumed losses in conveyance and distribution of the exchange water supply from the Lockeford Diversion would be negligible, since the conduit system serving the area north of the river would be concrete-lined. Therefore, the full amount of 30,000 acre-feet per season would be available for surface application to irrigable lands.

It should be pointed out that, although conveyance and distribution losses would reduce the acreage that could be irrigated from a surface supply, such losses would augment the ground water supply and would increase the acreage that would be irrigated from wells. This would follow, since the Western and Eastern Mokelume Units overlie a free ground water basin, wherein percolation of surface waters can occur. It was assumed, therefore, that these losses, plus the unconsumed portion of the new water supply applied to irrigation, would be effective in augmenting ground water supplies, thus preventing progressive lowering of ground water levels.

The seasonal application of irrigation water to crops in the Eastern and Western Mokelumne Units is estimated to be about 3.0 acre-feet per acre, based on plot studies of water application described in Chapter III. The indicated seasonal consumptive use of water applied to those lands would be about 1.6 acre-feet per acre. Based on these depths of application of water and consumptive use of applied water, and on the foregoing assumptions as to losses, lands in the Eastern Mokelumne Unit south and north of the river that could be served a surface supply with the exchange water would comprise about 7,500 acres and 10,000 acres, respectively. In addition, the diverted supplies would eliminate progressive lowering of ground water, and would provide new ground water supplies for about 6,900 acres and 4,400 acres of irrigable lands in the service areas south and north of the Mokelumne River, respectively.

Delta Diversion. Under the plan considered, diversion of water from the Sacramento-San Joaquin Delta would be made by an easterly extension of Sycamore Slough for a distance of about 13,000 feet to the site of a pumping plant. The extension would start at about the center of Section 34, Township 4 North, Range 5 East, M. D. B & M., and would end at about the northeast corner of the southeast quarter of Section 36, Township 4 North, Range 5 East, M. D. B. & M. The extension of Sycamore Slough would consist of an unlined canal, all in cut, and would have a capacity of 250 second-feet. The elevation of the bottom of the canal at its intake would be minus 5.7 feet, and at the pumping plant, minus 8.4 feet. The canal would be of trapezoidal section, with bottom width of 5 feet, and with side slopes of 2 : 1.

At the terminus of the canal the diverted water would enter a reinforced-concrete sump, equipped with trash racks. From the sump the water would be pumped to another canal extending to a point near Woodbridge. In order to permit flexibility in operation, the pumping plant would consist of a battery of six electrically-driven pumps, five of 30-inch diameter and with individual capacities of approximately 45 second-feet, and one of 24-inch diameter and about 28 second-foot capacity. The larger pumps would be driven by 300-horsepower motors, and the small pump by a 200-horsepower motor. The pumps would be of the vertical, axial-flow, and would operate under a maximum head of about 46 feet. The pumping units would be mounted on concrete piers, supported by steel ring girders, with pumping shafts and discharge lines laid on a slope of 2 : 1. The six shafts and pumps would be about 60 feet in length, extending from the pumping sump up the slope to the pump motors. The discharge lines would be about 90 feet in length, extending up the slope to the canal. The battery of pumps would be installed on a reinforced-concrete foundation supported by piling.

The concrete-lined canal into which the pumps would discharge would have a capacity of 250 second-feet, and would be about 16,000 feet in length. Water surface elevation in the canal at the pumping plant would be at about 42.5 feet, and at the canal terminus, in the northeast corner of the southeast quarter of Section 33, Township 4 North, Range 6 East, M. D. B. & M., the water surface elevation would be about 39 feet. The canal would be of trapezoidal section, with bottom width of 10 feet, depth of 5.5 feet, and with side slopes of 1.5 : 1. It would be in fill for a distance of about 11,500 feet from the pumping plant, with the remainder in cut. At the terminus, a concrete diversion box structure would be provided to release water into the various canal and lateral headings of the Woodbridge Irrigation District.

Clements Diversion. The site selected for diversion of Mokelumne River exchange water to the service area south of the river is at a point northeast of Clements, near the center of Section 14, Township 4 North, Range 8 East, M. D. B. & M. Water would be pumped from the Mokelumne River near this point, and conveyed to the service area by means of a partially lined canal extending southerly to and discharging into Bear Creek, from which creek the water could be pumped by existing and new pumps to serve lands lying adjacent to the creek. The lands which could be irrigated with the new water supply comprise the aforementioned 7,500 acres of land served with a surface supply, and the 6,900 acres supplied with new ground water, within the service area shown on Plate 17. The service area ranges in elevation from approximately 140 feet on the east to about 50 feet in the western portion.

The average rate of diversion during the peak demand month of July would be about 106 second-feet. The Clements Diversion, however, was designed with a total pumping capacity of about 135 second-feet, which capacity would meet the estimated monthly maximum rate of demand, and would provide additional capacity for shorter-term peaking in excess of the average monthly rate.

Under the plan considered, water from the Mokelumne River would be conveyed southerly for a distance of about 1,600 feet in an enlargement of an existing slough, to a reinforced-concrete pumping sump equipped with trash racks. From the sump, the water would be pumped up a slope to a sand trap at the intake of a canal. In order to permit flexibility in operation, the pumping plant would consist of three electrically driven vertical, axial-flow pumping units. Each of the units would consist of a 30-inch diameter pump with capacity of about 45 second-feet, driven by a 400-horsepower motor. The pumps would operate at a maximum pumping head of about 70 feet, pumping from an estimated minimum water surface elevation of about 79 feet to a discharge elevation of about 141 feet. The pumping units would be mounted on concrete piers, supported by steel ring girders, with pumping shafts laid on a slope of 2 : 1. The three shafts and pumps would be 142 feet in length, extending from the pumping sump up the slope to the sand trap. The battery of pumps would be operated from an 8-foot by 20-foot corrugated metal building, supported on a reinforced-concrete foundation.

The sand trap would be a reinforced-concrete structure, 30 feet by 25 feet in inside dimensions, and 11 feet in depth. It would be equipped with three 30-inch diameter slide sluice gates for discharging sand.

From the sand trap the water would be conveyed by gravity to Bear Creek in a partially concrete-lined canal, extending in a southerly direction along the top of a bluff. The canal would be lined with a 3-inch thickness of shotcrete for a distance of about 2,000 feet from its intake, to prevent seepage which might otherwise return to the Mokelumne River or damage crops near the toe of the bluff. This lined canal would be of trapezoidal section, with 1.5:1 side slopes, bottom width of 3.0 feet, depth of 5.3 feet, and 1.0-foot freeboard. The slope would be 4.0 feet per mile, the velocity about 4.5 feet per second, and the capacity would be 125 second-feet. At the end of the lined section, a 4-foot diameter corrugated metal pipe would convey the water under State Highway No. 12. The canal would be unlined for the distance of 2,000 feet from the highway to its terminus at Bear Creek. The unlined portion would be of trapezoidal section, with 2:1 side slopes, bottom width of 3.0 feet, depth of 5.8 feet, and 1.0-foot freeboard. The slope would be 3.2 feet per mile, the velocity about 2.5 feet per second, and the capacity would be 125 second-feet. The reinforced-concrete outlet structure at Bear Creek would have dimensions of 20 feet by 25 feet, with bottom elevation of about 127 feet and water surface elevation of about 131 feet. The outlet would include two 48-inch by 48-inch slide gates, to control releases of water from the canal. Design of works for distribution of water from Bear Creek was considered to be outside the scope of the current investigation.

Lockeford Diversion. The site selected for diversion of Mokelumne River water to the service area north of the river is at a point on the north bank about one mile northwest of Lockeford, in the southwest quarter of Section 24, Township 4 North, Range 7 East, M. D. B. & M. Water pumped from the river would be conveyed to the service area in a canal terminating in the northwest corner of the southwest quarter of Section 11, Township 4 North, Range 7 East, M. D. B. & M. Lands served would be furnished water by gravity en route. The lands which could be irrigated with the new supply comprise the aforementioned 10,000 acres served with a surface supply, and 4,400 acres supplied with ground water. The service area ranges in elevation from approximately 100 feet on the east to about 65 feet in the western portion.

The Lockeford Diversion was designed with a pumping capacity of about 135 second-feet. This installation would meet the estimated monthly maximum rate of demand of about 106 second-feet, and would provide additional capacity for shorter-term peaking in excess of the average monthly rate.

In order to permit flexibility in operation of the project, design of the pumping plant was based on the installation of three electrically driven vertical, axial-flow, pumping units. Each of the units would consist of a 30-inch diameter pump, with capacity of 45 second-feet, driven by a 250-horsepower motor. The pumps would operate at a maximum pumping head of about 45 feet, pumping from an estimated minimum water surface elevation of about 58 feet to a discharge elevation of about 100 feet. The pumping units would be mounted on concrete piers, supported by steel ring girders, with pumping shafts laid on a slope of 1.5:1. The three shafts and pumps would be about 75 feet in length, extending from the pump intake up the slope to a sand trap with sluice gates. The battery of pumps would be operated from a 12-foot by 20-foot corrugated metal building, supported on a reinforced-concrete foundation.

The sand trap would be a reinforced-concrete structure, 20 feet by 20 feet in inside dimensions, and 10 feet in depth. It would be equipped with two 36-inch diameter slide sluice gates for discharging sand.

From the sand trap the water would be conveyed by gravity in a northwesterly direction to the western boundary of Section 11, Township 4 North, Range 7 East, M. D. B. & M., in a concrete-lined canal about 19,000 feet in length. The canal would be of trapezoidal section, with 1.5:1 side slopes, bottom width of 5.0 feet, depth of 4.9 feet, and 1.0-foot freeboard. The slope would be 1.5 feet per mile, the velocity about 3.0 feet per second, and the capacity would be 125 second-feet. At the end of the canal a reinforced-concrete headgate structure would be provided, having inside dimensions of 11 feet by 20 feet, and being 5.5 feet in depth. The structure would be provided with two 5-foot by 5-foot slide headgates. The elevation of the bottom of the headgate structure would be 90 feet, with maximum water surface elevation of about 95 feet. Design of works for distribution of water from the canal was considered to be outside the scope of the current investigation.

Summary of General Features of Delta-Mokelumne River Diversion Project. Pertinent data with respect to general features of the Delta-Mokelumne River Diversion Project, as designed for cost estimating purposes, are presented in Table 43.

Capital cost of the Delta-Mokelumne River Diversion Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be about $1,784,000, and corresponding annual costs were estimated to be about $191,000. Resultant estimated average unit cost of the 60,000 acre-feet of new irrigation yield per season was about $3.20 per acre-foot, not including costs for firming up the diverted supply from the Delta with water from the Feather River or Folsom Projects. On a 4 per cent interest basis the unit cost of new irrigation yield per season was about $3.40 per acre-foot.

TABLE 43

GENERAL FEATURES OF DELTA-MOKELUMNE RIVER DIVERSION PROJECT

Pumping Plants
- Delta Diversion
  - Pumps—5 vertical, axial-flow, 45 second-foot capacity each
    1 vertical, axial-flow, 28 second-foot capacity
  - Estimated minimum water surface elevation at end of extension of Sycamore Slough—Minus 1.0 foot
  - Discharge elevation—42.5 feet
  - Estimated maximum pumping head—46 feet
  - Installed pumping capacity—253 second-feet
  - Estimated maximum monthly demand—213 second-feet
  - Estimated gross seasonal diversion—60,000 acre-feet
  - Motors—5 all-weather type, 300-horsepower each
    1 all-weather type, 200-horsepower
  - Pump support—Concrete piers, with steel ring girders
  - Pumping sump—Reinforced concrete, 10 feet by 60 feet, 10 feet in depth, equipped with trash racks
- Clements Diversion
  - Pumps—3 vertical, axial-flow, 45 second-foot capacity each
  - Estimated minimum water surface elevation at end of enlarged slough of Mokelumne River—79 feet
  - Discharge elevation—141 feet
  - Estimated maximum pumping head—70 feet
  - Installed pumping capacity—135 second-feet
  - Estimated maximum monthly demand—106 second-feet
  - Estimated gross seasonal diversion—30,000 acre-feet
  - Motors—3 all-weather type, 400-horsepower each
  - Pump support—Concrete piers, with steel ring girders
  - Pumping sump—Reinforced concrete, 10 feet by 15 feet, 10 feet in depth, equipped with trash racks
  - Sand trap—Reinforced concrete, 25 feet by 30 feet, 11 feet in depth, equipped with baffles and sluice gates
- Lockeford Diversion
  - Pumps—3 vertical, axial-flow, 45 second-foot capacity each
  - Estimated minimum water surface elevation in Mokelumne River—58 feet
  - Discharge elevation—100 feet
  - Estimated maximum pumping head—45 feet
  - Installed pumping capacity—135 second-feet
  - Estimated maximum monthly demand—106 second-feet
  - Estimated gross seasonal diversion—30,000 acre-feet
  - Motors—3 all-weather type, 250-horsepower each
  - Pump support—Concrete piers with steel ring girders
  - Pumping sump—Reinforced concrete, 12 feet by 20 feet, 8 feet in depth, equipped with trash racks
  - Sand trap—Reinforced concrete, 20 feet by 20 feet, 10 feet in depth, equipped with baffles and sluice gates

Conveyance System

	Delta Diversion		Clements Diversion		Lockeford Diversion
Type	Trapezoidal, unlined	Trapezoidal, concrete-lined	Trapezoidal, unlined	Trapezoidal, concrete-lined	Trapezoidal, concrete-lined
Length, in miles	2.5	3.0	0.4	0.4	3.6
Side slopes	2:1	1.5:1	2:1	1.5:1	1.5:1
Bottom width, in feet	5.0	10.0	3.0	3.0	5.0
Depth, in feet	variable, 6.7 to 11.7	6.5	5.8	5.3	4.9
Freeboard, in feet	variable	1.0	1.0	1.0	1.0
Slope, in feet per mile	1.1	1.4	3.2	4.0	1.5
Velocity, in feet per second	2.0	3.5	2.5	4.5	3.0
Capacity, in second-feet	250	250	125	125	125

Estimated capital and annual costs of the Delta-Mokelumne River Diversion Project on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs Capital	Annual
Delta Diversion		
Pumping plant	$223,000	$62,000
Conveyance system	910,000	40,000
Subtotals	$1,133,000	$102,000
Clements Diversion		
Pumping plant	$144,000	$43,000
Conveyance system	62,000	3,000
Subtotals	$206,000	$46,000
Lockeford Diversion		
Pumping plant	$99,000	$28,000
Conveyance system	346,000	15,000
Subtotals	$445,000	$43,000
TOTALS	$1,784,000	$191,000

Mokelumne River Project

Satisfactory sites for pumped diversion of surplus water from the Mokelumne River, for benefit of the Eastern Mokelumne Unit, exist at points near Clements and near Lockeford to serve lands lying south and north, respectively, of the Mokelumne River. Under this project water would be pumped from the Mokelumne River at the Clement site, and conveyed to the area south of the river by means of a partially lined canal extending southerly to and discharging into Bear Creek. Water pumped from the Mokelumne River at the Lockeford site would be conveyed in a canal terminating in Section 11, Township 4 North, Range 7 East, M. D. B. & M. Lands served would be furnished water by gravity enroute. This plan is hereinafter referred to as the "Mokelumne River Project," and its principal features are designated "Clements Diversion" and "Lockeford Diversion." These features are shown on Plate 17, which shows the principal features of the Delta-Mokelumne River Diversion Project.

The Mokelumne River Project was designed to provide a total seasonal diversion of 31,000 acre-feet of supplemental water, which would more than meet the present supplemental water requirement of the Eastern Mokelumne Unit. Studies indicate that in order to divert an average of about 31,000 acre-feet of surplus water seasonally from the Mokelumne River, a rate of diversion of 250 second-feet, when available, would be required from April through October. A summary of the yield study made for the project is given in Appendix K.

The determination of the amount of surplus water available in the Mokelumne River was based on the assumptions that full seasonal diversions under present entitlements would be made by the Calaveras Public Utility District, the Pacific Gas and Electric Company through the Amador Canal, and the East Bay Municipal Utility District, in the amounts of 9,000 acre-feet, 15,000 acre-feet, and 224,000 acre-feet, respectively. It was assumed further that Pardee Reservoir would be operated in the manner presently proposed by the East Bay Municipal Utility District, that present riparian and appropriative rights downstream from Pardee Reservoir would be met as would river losses between the reservoir and Woodbridge Diversion Dam, and that the variable seasonal diversion made by the Woodbridge Irrigation District would amount to a maximum of about 149,000 acre-feet, based on a maximum diversion capacity of 450 second-feet and the irrigation demand schedule set forth in Table 39. The studies indicated that from April through October, during the period from 1924 through 1951, surplus water would be available only in 1 month for 3 years, available 2 months for 2 years, available 3 months for 14 years, and available in 4 months for 3 years. The studies further indicated that no surplus water would be available for diversion for 6 years. In no year during the period would surplus water be available in August, September, and October.

The yield of the Mokelumne River Project was allocated equally as between the two service areas, for purposes of this study. Lands south of the Mokelumne River would be supplied an average of 15,500 acre-feet of new water per season by the Clements Diversion, while lands north of the river would be served an average of 15,500 acre-feet by the Lockeford Diversion. Percolation losses in the unlined canals of the Clements Diversion were estimated to be 25 per cent, leaving some 11,200 acre-feet of water per season for application to irrigated lands. Losses in the lined canals of the Lockeford Diversion were considered negligible. The capacities of pumping plants and canals for the Clements and Lockeford Diversions were based on the estimated continuous monthly diversion of 7,500 acre-feet each, if available, or a continuous flow equivalent of 125 second-feet. However, the diversions were designed with total capacities of 135 second-feet each, in order to provide additional capacity for short-term peaking in excess of the average monthly rate.

Based on a seasonal irrigation application of 3.0 acre-feet per acre, the new water supply could serve an average of 3,700 and 5,000 acres south and north of the Mokelumne River, respectively. Furthermore, based on an estimated seasonal consumption of applied water of 1.6 acre-feet per acre, percolation of the unconsumed portion of applied water, plus canal percolation losses, would augment ground water supplies by an average of some 9,600 acre-feet and 7,500 acre-feet per season in the areas south and north of the river, respectively.

The Clements and Lockeford Diversions, which would serve the areas in the Eastern Mokelumne Unit south and north of the Mokelumne River, have been described in detail for the Delta-Mokelumne Diversion Project in a previous section. Since the described features, sizes and locations of pumping plants, and routes of canals, are the same for the

Iokelumne River Project, they are not described in letail again.

Capital cost of the Mokelumne River Project, on a 3 per cent interest basis, and with prices prevailing n April, 1953, was estimated to be about $651,000, nd corresponding annual costs were estimated to be bout $64,000. The resultant estimated average unit ost of the average of 31,000 acre-feet of new irrigaion water per season was about $2.10 per acre-foot. On a 4 per cent interest basis, the unit cost of new vater per season was about $2.20 per acre-foot. The oregoing estimates of costs do not include costs of aterals, turnouts, and other facilities, required to leliver the water to areas of use, nor do they include osts of standby ground water pumping wells. Under he Mokelumne River Project, a duplicate surface listribution system and ground water well system vould be required, since in all years no surplus water vould be available for diversion from the Mokelumne River during every month of the irrigation season. Should water users in the Eastern Mokelumne Unit lect to also irrigate their lands during the nonirrigaion season, or acquire lands suitable for spreading f water for ground water replenishment during the nonirrigation season, additional new water could be nade available from surplus flows in the Mokelumne River.

Estimated capital and annual costs of the Mokelmne River Project on a 3 per cent interest basis are ummarized in the following tabulation. Detailed cost stimates are presented in Appendix L under the Delta-Mokelumne River Diversion Project, modified, owever, for differences in annual pumping energy harges.

	Estimated Costs	
	Capital	*Annual*
Clements Diversion		
Pumping plant	$144,000	$27,000
Conveyance system	62,000	3,000
Subtotals	$206,000	$30,000
Lockeford Diversion		
Pumping plant	$99,000	$19,000
Conveyance system	346,000	15,000
Subtotals	$445,000	$34,000
TOTALS	$651,000	$64,000

Mehrten Project

Construction of a dam and reservoir on the Mokelmne River at the Mehrten site, with appropriate ownstream diversion and conveyance facilities, vould provide new irrigation yield to meet a portion f the estimated present supplemental requirement n the Eastern Mokelumne Unit. Use of the new water upply would also reduce progressive lowering of round water levels in the areas served. The Mehrten ite is located about 3.5 miles upstream from Clemnts, in Section 6, Township 4 North, Range 9 East, I. D. B. & M. The proposed Mehrten Dam would be an earthfill structure, with a circular ogee weir spillway. Stream bed elevation at the dam site is about 85 feet. Flood waters of the Mokelumne River, conserved by the reservoir and released on a demand schedule during the irrigation season, would be available downstream for diversion and conveyance to service areas south and north of the Mokelumne River, by the Clements Diversion and the Lockeford Diversion, respectively. This plan is hereinafter referred to as the "Mehrten Project," and its principal features are delineated on Plate 18, entitled "Mehrten Project." The North San Joaquin Water Conservation District has made application to the State Engineer to appropriate Mokelumne River water, by construction of a dam and reservoir at the Mehrten site, and conveyance of the conserved water to the Eastern Mokelumne Unit for irrigation, domestic, municipal, recreational, and industrial purposes.

It was estimated that mean seasonal natural runoff of the Mokelumne River, from the approximately 625 square miles above the Mehrten dam site, is about 780,000 acre-feet. Based upon yield studies during the critical dry period which occurred from 1927-28 through 1934-35, together with topography of the dam site and cost analyses hereinafter discussed, a reservoir of 50,000 acre-foot storage capacity, with estimated new seasonal irrigation yield of 13,700 acrefeet, was chosen for purposes of cost estimates to be presented in this bulletin. The yield study for this size reservoir is included in Appendix K.

The yield of the Mehrten Project was allocated equally as between the two service areas, for purposes of this study. Lands south of the Mokelumne River would be served 6,800 acre-feet of new water per season by the Clements Diversion, while lands north of the river would be served 6,900 acre-feet by the Lockeford Diversion. Percolation losses in the unlined canals of the Clements Diversion were estimated to be 25 per cent, leaving some 5,100 acre-feet of water per season for application to irrigated lands. Losses in the lined canals of the Lockeford Diversion were considered negligible. The capacities of pumping plants and canals for the Clements and Lockeford Diversions were based on the estimated maximum monthly diversion of 1,440 acre-feet of water during July. The continuous flow equivalent of this diversion would be 24 second-feet.

Based on a seasonal irrigation application of 3.0 acre-feet per acre, the new water supply could serve 1,700 acres and 2,300 acres south and north of the Mokelumne River, respectively. Furthermore, based on an estimated seasonal consumption of applied water of 1.6 acre-feet per acre, percolation of the unconsumed portion of applied irrigation water, plus canal percolation losses, would augment ground water supplies by some 4,100 acre-feet and 3,200 acre-feet in the areas south and north of the river, respectively.

A topographic survey of the Mehrten reservoir site up to an elevation of 175 feet was made by W. R. Daniels of San Francisco in 1924 and 1927, and a map was drawn to a scale of 1 inch equals 200 feet, with a contour interval of 5 feet. Storage capacities of the Mehrten Reservoir at various stages of water surface elevation are given in Table 44.

TABLE 44

AREA AND CAPACITIES OF MEHRTEN RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	85	0	0
5	90	12	60
15	100	59	440
25	110	295	2,010
35	120	700	6,840
45	130	1,018	15,320
55	140	1,454	27,770
65	150	1,968	44,870
67	152	2,100	50,000
75	160	2,582	67,700
85	170	3,440	97,730

Based upon preliminary geological reconnaissance, the Mehrten dam site is considered to be suitable for an earthfill dam of any height up to a maximum of about 85 feet. Construction materials for such a structure are available nearby. Impervious fill could be obtained from a number of undisturbed silt and gravel terraces which occur within the reservoir area at the edges of the channel section. Additional supplies of earth could be stripped in thin layers from uneven ground adjacent to the river channel within feasible haul distances of the site. Dredger tailings from the channel section upstream should prove excellent for use in stability sections of the dam. Cobbles of the tailings range from 2 to 10 inches in diameter, and the deposits are relatively clean and free of fines.

Bedrock consists of a flat-lying series of fine- to medium-grained sediments of the Mehrten formation. These are chiefly andesitic siltstones and sandstones of fluvial origin. The beds lie relatively flat, with a very gentle dip downstream and slightly into the left abutment. Some cross-bedding of the sediments also exists. The rocks are moderately well-cemented in some layers and poorly so in others. They are generally quite friable, however. Many of the beds contain a few pebbles and small cobbles of andesite and other volcanic and basic igneous rocks. No joints or shears were noted in the sediments, although some relatively tight but small seams undoubtedly do occur there. The channel locally is choked with older dredger tailings, and no bedrock outcrops either there or on the right abutment, which is covered by a light soil overburden. Stripping on the right abutment, normal to the surface, should consist only of about four feet of overburden, and on the left abutment of about one foot of soil and weathered bedrock. This would all be classed as common excavation. Thickness of the dredger tailings is not known, but indications are that they should not exceed 25 feet in depth. Considerable leakage through the sediments of the Mehrten and underlying formations may occur in this area.

A backfilled earthen cutoff trench, having sufficient depth to satisfactorily increase the path of percolation beneath the dam, should be employed both under the channel section and part way up the abutments. The foundation rock may prove to be relatively permeable, and the proposed dam should be designed with this in mind. Further investigation may indicate that blanketing of both abutments would be required. Furthermore, it is probable that relief wells would be required at the downstream toe of the dam. Depth of the overburden on the right abutment can only be accurately determined by means of exploration. Trenching by bulldozer should prove the easiest and most effective method of determining this depth. Exploration of the channel section to determine the exact depth of the fill therein should also be considered as part of the preliminary investigation at this site. Slant drilling from the abutments might prove to be the best means of determining this depth of fill, as well as the possible existence of any weak zones under the fill.

A spillway could be placed across flat land occurring adjacent to either abutment. Further investigation may indicate that the spillway should be located some distance from either abutment. Indications are that the spillway cuts would encounter relatively little bedrock. Lining of the entire spillway channel would be necessary to prevent undue erosion of the soft materials through which the cut would be made.

A number of ranches lie within the proposed reservoir area. These consist mostly of old buildings, with very little improved land. Most of the reservoir area consists of grazing land of poor quality. Buildings of the Gold Hill Dredging Company and company employees' residences would be inundated. There are several paved and dirt roads crossing the Mokelumne River above the dam site, which would be inundated.

As a result of yield studies, geologic reconnaissance, and preliminary economic analysis, an earthfill dam, 67 feet in height from stream bed to spillway lip, and with a crest elevation of 170 feet, was selected to illustrate estimates of costs of the Mehrten Project. The dam would have a crest length of about 1,000 feet and a crest width of 30 feet, and 3:1 upstream and 2:1 downstream slopes. The central impervious core would have a top width of 10 feet and 0.8:1 slopes. The upstream pervious zones of the dam would consist of random fill, while the downstream zone would consist of dredger tailings. A 5-foot blanket of large dredger tailings for riprap would protect the upstream face of the dam. The volume of fill would be an estimated 575,000 cubic yards.

The spillway would be a circular ogee weir, with a concrete-lined chute located across the ridge forming the right abutment. The maximum depth of water above the spillway lip would be 13 feet, and an additional 5 feet of freeboard would be provided. The spillway would have a capacity of 100,000 second-feet, required for an assumed maximum discharge of 160 second-feet per square mile of drainage area. The spillway would discharge into the Mokelumne River about 1,000 feet downstream from the toe of the dam.

Two small auxiliary dams would be required. One of the dams would be located to the right of the spillway, while the other would be situated in a drain near the left abutment of the dam. The auxiliary dams would consist of rolled earth sections, with 20-foot crest widths and 2:1 side slopes. Total crest length of the two dams would be about 1,400 feet, and the maximum height of fill would be about 20 feet. The central impervious core section of the auxiliary dams would have a top width of 8 feet, and side slopes of 0.8:1. The outer pervious sections would consist of dredger tailings. It was estimated that about five feet of overburden would have to be stripped from under the auxiliary dams. The total volume of fill in the two dams would be an estimated 46,000 cubic yards.

The outlet works would be located at stream bed elevation, and would include a steel pipe, 8 feet in diameter and 400 feet in length, placed in a trench excavated through the left abutment and encased in concrete. The intake structure would consist of a reinforced-concrete box 10 feet in height, 10 feet wide, and 20 feet long, and would be supported on piles. Steel bars would be placed on the sides and top of the structure, to form a trash rack. Releases of water from the reservoir would be controlled by means of four 60-inch low-pressure, motor-driven slide gates, located at a section of the outlet beneath the dam wherein the 8-foot diameter pipe branches to two 6-foot diameter pipes and then returns to the single pipe of 7-foot diameter. The motors would be installed in a control house located upstream from the crest of the dam near the left abutment. The control house would be approached from the dam by means of a wooden footbridge. An apron with training walls, and concrete tetrahedron baffle located at the center of the apron, would be constructed at the end of the outlet pipe in order to dissipate the energy of water released through the dam. The apron would be about 30 feet long and 24 feet wide. The tetrahedron baffle would be about 8 feet high.

As previously stated, the Clements and Lockeford Diversions would serve the area in the Eastern Mokelumne Unit south and north of the Mokelumne River. These diversions have been described in detail for the Delta-Mokelumne Diversion Project in a previous section. Since the described features, locations of pumping plants, and routes of canals are the same for the Mehrten Project, and differ only in size of works required, they are not described in detail herein. However, pertinent data with respect to sizes of these features of the Mehrten Project as designed for cost estimating purposes, are presented in Table 45.

TABLE 45

GENERAL FEATURES OF MEHRTEN PROJECT

Earthfill Dam
- Crest elevation—170 feet
- Crest length—1,000 feet
- Crest width—30 feet
- Height, spillway lip above stream bed—67 feet
- Side slopes—3:1 upstream
  2:1 downstream
- Freeboard, above spillway lip—18 feet
- Elevation of stream bed—85 feet
- Volume of fill—575,000 cubic yards

Reservoir
- Surface area at spillway lip—2,100 acres
- Capacity at spillway lip—50,000 acre-feet
- Drainage area—625 square miles
- Estimated mean seasonal runoff—780,000 acre-feet
- Estimated new seasonal irrigation yield—13,700 acre-feet
- Type of spillway—Concrete-lined ogee weir and chute
- Spillway capacity—100,000 second-feet
- Type of outlet—8-foot diameter steel pipe through left abutment and encased in concrete

Pumping Plants

Clements Diversion
- Pumps—2 vertical, axial-flow, 13.5 second-foot capacity each
- Estimated minimum water surface elevation at end of enlarged slough of Mokelumne River—79 feet
- Discharge elevation—135 feet
- Estimated maximum pumping head—65 feet
- Installed pumping capacity—27 second-feet
- Estimated maximum monthly demand—24 second-feet
- Estimated gross seasonal diversion—6,850 acre-feet
- Motors—2 all-weather type, 100-horsepower each
- Pump support—Concrete piers, with steel ring girders
- Pumping sump—Reinforced concrete, 10 feet by 15 feet, 10 feet in depth, equipped with trash racks
- Sand trap—Reinforced concrete, 25 feet by 30 feet, 11 feet in depth, equipped with baffles and sluice gates

Lockeford Diversion
- Pumps—2 vertical, axial-flow, 13.5 second-foot capacity each
- Estimated minimum water surface elevation in Mokelumne River—58 feet
- Discharge elevation—99 feet
- Estimated maximum pumping head—44 feet
- Installed pumping capacity—27 second-feet
- Estimated maximum monthly demand—24 second-feet
- Estimated gross seasonal diversion—6,850 acre-feet
- Motors—2 all-weather type, 100-horsepower each
- Pump support—Concrete piers, with steel ring girders
- Pumping sump—Reinforced concrete, 10 feet by 12 feet, 10 feet in depth, equipped with trash racks
- Sand trap—Reinforced concrete, 10 feet by 12 feet, 8 feet in depth, equipped with baffle and sluice gates

Conduits

	Clements Diversion		Lockeford Diversion
Type	Trapezoidal, lined section	Trapezoidal, unlined section	Trapezoidal, lined section
Length, in miles	0.4	0.4	3.6
Side slopes	1.5:1	2:1	1.1:1
Bottom width, in feet	3.0	3.0	3.0
Depth, in feet	2.4	2.6	3.4
Freeboard, in feet	1.0	1.0	1.0
Slope, in feet per mile	4.0	7.9	1.4
Velocity, in feet per second	3.6	2.5	2.0
Capacity, in second-feet	25	25	25

The capital cost of the Mehrten Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be about $4,007,000. The corresponding annual costs were estimated to be about $183,000. The resultant estimated unit cost of the 13,700 acre-feet per season of new irrigation yield from the Mehrten Project was about $13.30 per acre-foot. On a 4 per cent interest basis the unit cost of new irrigation yield per season was about $15.60 per acre-foot.

Estimated capital and annual costs of the Mehrten Project on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
Mehrten Dam and Reservoir	$3,698,000	$154,000
Clements Diversion		
Pumping plant	$36,000	$10,000
Conveyance system	47,000	2,000
Subtotals	$83,000	$12,000
Lockeford Diversion		
Pumping plant	$32,000	$8,000
Conveyance system	194,000	9,000
Subtotals	$226,000	$17,000
TOTALS	$4,007,000	$183,000

Camanche Project

Construction of a dam and reservoir at the Camanche site on the Mokelumne River, with appropriate downstream diversion and conveyance facilities, would provide new water to meet the present supplemental water requirement of 28,500 acre-feet per season in the Eastern Mokelumne Unit, and for growth in water utilization for a number of years into the future. This project would also provide new water for use in the Western Mokelumne Unit, which needs no supplemental water at present but which will in the future. Use of the new surface water supply would prevent progressive lowering of ground water levels in the areas served. In addition, revenue could be secured by construction and operation of a hydroelectric power plant at the dam. The Camanche site is located in Section 6, Township 4 North, Range 9 East, M. D. B. & M., about seven miles downstream from Pardee Dam and 1.5 miles west of the San Joaquin-Calaveras county line. This project is hereinafter referred to as the "Camanche Project," and its principal features are delineated on Plate 19, entitled "Camanche Project." The East Bay Municipal Utility District has made application to the State Engineer to appropriate Mokelumne River water by construction of a dam and reservoir at the Camanche site and conveyance of the conserved water to the East San Francisco Bay area for municipal purposes.

Consideration was given to the operation of the Camanche Project in the interest of flood control. However, it was found that the reservation of flood control space believed to be required in Camanche Reservoir would substantially reduce the yield of water from the project. Furthermore, the comprehensive survey report of the Corps of Engineers, dated February 1, 1945, and its supplement dated June 1, 1948, indicate that of the number of alternatives investigated for control of floods on the Mokelumne River, the most feasible plan appears to be the diversion of a portion of the surplus flood waters of the Mokelumne River into a possible Ione Dam and Reservoir on Dry Creek. Such diversion could be accomplished by minor modification in the existing auxiliary spillway at Pardee Dam, and by the provision of a diversion channel. For these reasons no further consideration was given to the possible reservation of flood control space in possible reservoirs considered on the main stem of the Mokelumne River.

The proposed Camanche Dam would be an earthfill structure, with seven earthen auxiliary saddle dikes, and a chute-type spillway. Stream bed elevation at the dam site is about 90 feet. Flood waters of the Mokelumne River, conserved by the proposed reservoir and released on a demand schedule during the irrigation season, would pass through the hydroelectric power plant. The waters would then be available downstream for diversion and conveyance to service areas south and north of the Mokelumne River by the Clements and Lockeford Diversions, respectively. Additional water for the Western Mokelumne Unit would be diverted by gravity at the existing Woodbridge Diversion Dam.

It was estimated that the mean seasonal natural runoff of the Mokelumne River, from the 625 square miles of watershed above the dam site, is about 780,000 acre-feet. Based upon yield studies during the critical dry period which occurred from 1927-28 through 1933-34, together with topography of the dam site and cost analyses hereinafter discussed, a reservoir of 212,000 acre-foot storage capacity, with estimated new seasonal irrigation yield of 52,000 acre-feet, was chosen for cost estimates to be presented in this bulletin. The yield study for this size of reservoir is included in Appendix K.

For purposes of this study, the seasonal yield of the Camanche Project was allocated as follows: 20,000 acre-feet to the service area south of the Mokelumne River and 20,000 acre-feet to the service area north of the river, both in the Eastern Mokelumne Unit, and 12,000 acre-feet to the Western Mokelumne Unit. It was estimated that losses of water in conveyance and distribution of the 20,000 acre-feet of new seasonal irrigation yield to the service area south of the Mokelumne River in the unlined canals and ditches of the Clements Diversion would be about 25 per cent, leaving some 15,000 acre-feet of water per season for application to irrigated lands. Losses in conveyance of the 20,000 acre-feet of new seasonal irrigation yield to the service area north of the Mokelumne River in the concrete-lined canals of the Lockeford Diversion were assumed to be negligible. The full 20,000 acre-feet per season, therefore, would be available for application to irrigated lands. A conveyance and distribution loss of 25 per cent of the 12,000 acre-feet of new seasonal irrigation yield assigned to the Western Mokelumne Unit was estimated, as the existing canals in this unit are generally unlined, leaving some 9,000 acre-feet of water per season for application to irrigated lands.

The design of the Clements and Lockeford Diversions was based on the estimated maximum monthly diversion demand which, as shown in Table 39, occurs in July, and amounts to 22 per cent of the total seasonal diversion. Capacities of 75 second-feet for the Clements and Lockeford Diversions were selected from the foregoing data.

Based on a seasonal irrigation application of 3.0 acre-feet per acre, the new water supply could serve 5,000 acres and 6,700 acres south and north, respectively, of the Mokelumne River, and 3,000 acres in the Western Mokelumne Unit. Furthermore, based on estimated seasonal consumption of applied water of 1.6 acre-feet per acre, percolation of the unconsumed portion of applied irrigation water, plus canal percolation losses, would augment ground water supplies by some 12,000 acre-feet and 9,300 acre-feet in the areas south and north of the river, respectively, in the Eastern Mokelumne Unit, and by 7,200 acre-feet in the Western Mokelumne Unit.

A topographic survey of the Camanche reservoir site up to an elevation of 300 feet was made by the East Bay Municipal Utility District in 1951, and a map was drawn to a scale of 1 inch equals 400 feet, with a contour interval of 10 feet. Storage capacities of the Camanche Reservoir at various stages of water surface elevation are given in Table 46.

TABLE 46

AREAS AND CAPACITIES OF CAMANCHE RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	90	0	0
10	100	30	100
20	110	170	1,500
30	120	560	4,500
40	130	900	12,000
50	140	1,270	23,000
60	150	1,580	37,000
70	160	2,000	54,000
80	170	2,900	78,000
90	180	3,730	111,000
100	190	4,400	153,000
112	202	5,340	212,000
120	210	5,900	254,000
130	220	6,600	320,000

Based upon preliminary geological reconnaissance, the Camanche dam site is considered suitable for an earthfill dam up to a maximum height of about 130 feet. The rock consists of a series of variable continental sediments, ranging from sandy silts to medium-grained sands to dirty gravels, which are probably a part of the Mehrten and Valley Springs formations of Tertiary age. The sediments are soft and friable, having little or no cementation. The nature of the material prohibits the ready detection of shears, although both jointing and spalling appeared to be developed to near maximum for the type of material involved. Animal borings through the soft sediments, and root holes and wedgings occur repeatedly. Some alkaline leaching in the sands and silts indicates at least a moderately high degree of permeability. Considerable leakage from the reservoir area may, therefore, be expected to occur through these formations. The sediments in the foundation area are essentially horizontally bedded, but dip very slightly downstream. Stripping of about 15 feet normal to the ground surface probably would be required over most of the abutments under the impervious section of the proposed earthfill dam. Stripping of as much as 40 feet from the channel section would be required, consisting chiefly of dredger tailings. Exact depth of the channel fill would have to be determined by further exploration at the site, possibly in the form of slant drilling under the channel section.

The spillway could be cut through saddles occurring behind either abutment. Foundation conditions should be similar in any of these locations, with cuts being partly in soil and partly in poorly consolidated sedimentary strata. Lining of the spillway channel would be necessary in any case.

Construction materials for the proposed dam are available within reasonable haul distances. Impervious fill could be obtained from the many terrace deposits which line both sides of the channel section within the reservoir area. Additional earthfill, if needed, could be stripped in thin layers from the surface of uneven ground adjacent to the river channel in this vicinity. Great piles of tailings choke the channel section, where the aforementioned terraces have been dredged for gold. These tailings consist mainly of cobbles up to 10 inches in diameter, and should prove excellent for use in the pervious sections of the dam.

Some 50 homes and a considerable number of farm buildings would be inundated by a reservoir of the chosen capacity at the Camanche site. In addition, about 15 miles of county road, 27 miles of telephone and electric lines and a power substation, and a wax manufacturing plant would require relocation. Lands within the reservoir area include about 350 acres of irrigated bottom lands, 1,000 acres of good grazing lands, and some 5,000 acres of grazing land of relatively poor quality.

As a result of yield studies, geologic reconnaissance, and preliminary economic analysis, an earthfill dam, 112 feet in height from stream bed to spillway lip, and with a crest elevation of 220 feet, was selected to illustrate estimates of cost of the Camanche Project. The dam would consist of eight earthfill structures, a main dam across the Mokelumne River and seven auxiliary saddle dams. The main dam would have a crest length of about 1,600 feet, a crest width of 30 feet, and 3:1 upstream and 2:1 downstream slopes. The central impervious core would have a top width of 10 feet and 0.8:1 slopes. The downstream outer pervious zone of the main dam would consist of materials salvaged from stripping from under the impervious section, and dredger tailings from the river bed. The upstream section of the dam would be a random fill with material obtained from the excavation of the spillway. The upstream slope of the dam would be faced with 5 feet of riprap.

Because of the permeability of the foundation material on which the dam would be constructed, wing sections extending upstream on both abutments would be necessary. The wing sections would consist of an impervious zone placed against the slopes of the abutments, and blanketed with pervious fill, and would extend upstream for a distance of about 500 feet. Stripping to a depth of 5 feet on the slopes would be required before placing the impervious fill. Pressure relief wells would be required at the downstream toe of the dam to reduce the effects of hydrostatic uplift. Twenty-two such wells, each with a diameter of 12 inches, would be drilled at intervals of 50 feet across the stream channel at the downstream toe of the dam. The total volume of fill in the main dam, including the wing sections, would be an estimated 3,252,000 cubic yards.

The crest lengths of the seven auxiliary saddle dams would vary from 100 feet to 2,650 feet, and would aggregate some 10,100 feet. The heights of the saddle dams would range from 5 feet to 55 feet. The crest width of each would be 20 feet, and the side slopes would be 2.5:1. The volumes of fill in the saddle dams would vary from 500 cubic yards to 438,400 cubic yards, and would total some 1,260,000 cubic yards. The upstream face of each saddle dam would be protected by a 4-foot blanket of rock riprap, while the downstream faces would be similarly protected by a 2-foot blanket. A summary of the heights, crest lengths, and volumes of fill of the seven auxiliary saddle dams is presented in Table 47.

The concrete spillway would be of the chute type with an ogee weir, located through a saddle on the left abutment. The maximum depth of water above the spillway lip would be 13 feet, and an additional 5 feet of freeboard would be provided. The spillway would have a capacity of 77,000 second-feet, based on a flood runoff of 125 second-feet per square mile of watershed above the dam. The control structure of the spillway would be a curved ogee weir with a crest length of 470 feet, and would be followed by 1,000 feet of concrete-lined chute with a stilling basin at the lower end. In addition, a channel with bottom elevation of about 186 feet would be provided in the center of the spillway section. The channel would be 50 feet wide and its depth would be 16 feet below the spillway lip elevation of 202 feet. The channel would be provided with a radial gate, 50 feet wide and 16 feet in height, to control flood releases up to 8,000 second-feet. Controlled releases through the channel would discharge into the main spillway chute. The radial gate would be open when the reservoir stage exceeded 202 feet and the spillway was passing flood waters.

TABLE 47

SUMMARY OF HEIGHTS, CREST LENGTHS, AND VOLUMES OF FILL OF SEVEN AUXILIARY SADDLE DAMS OF CAMANCHE RESERVOIR

Saddle dam, number on Plate 19	Height, in in feet	Crest length, in feet	Volume of fill, in cubic yards
1	20	2,650	264,500
2	35	1,230	140,100
3	55	1,440	294,700
4	34	600	54,400
5	35	100	67,200
6	45	3,980	438,400
7	5	100	500
TOTALS		10,100	1,259,800

The outlet works would consist of a 10-foot diameter steel pipe, which would branch into two 7-foot diameter steel pipes at the axis of the dam, with control valves at the transition section and at the downstream end of the 7-foot diameter pipes. The 10-foot diameter steel pipe would be laid in a trench excavated under the right abutment of the dam and encased in concrete, and would be 750 feet in length. Trash racks at the intake would, in addition to screening trash, reduce the intake velocity. The transition section and control house would be located under the central portion of the dam, at which point the discharge from the 10-foot diameter pipe would be divided at a wye into two 7-foot diameter steel pipes, both encased in concrete and each 380 feet in length. One of these pipes would serve as a penstock to the power plant. A walkway would be provided between the two pipes from the downstream toe of the dam to the control house for access to the controls. Releases of water from the reservoir would be controlled by two 6-foot by 6-foot high-pressure hydraulically operated slide gates at the transition section. Capacity of the outlet works would be 1,200 second-feet, and the maximum capacity of the penstock would be 600 second-feet.

A hydroelectric power plant, of 4,000-kilowatt installed power capacity, would be located 100 feet downstream from the right abutment of the dam. The power plant would operate on a load factor of 50 per cent at a design head of 80 feet, with a discharge of 600 second-feet. The dependable power capacity of the Camanche Power Plant would be about 2,400 kilowatts, and its average annual energy output would be about 18,500,000 kilowatt-hours. The power plant would be housed in a reinforced-concrete structure 70 feet in height, 60 feet in length, and 50 feet in width. Water released from the power plant would be returned to the Mokelumne River immediately downstream from the plant.

New water from the Mokelumne River would be served to areas in the Eastern Mokelume Unit south and north of the river by the Clements and Lockeford Diversions, which have been described in detail in a previous section pertaining to the Delta-Mokelumne River Diversion Project. The general features, locations of pumping plants, and routes of canals for these diversions would be the same for the Camanche Project, and would be designed for a capacity of 75 second-feet north and south of the river, respectively. Curves were prepared relating capacities of pumping plants and conveyance systems to costs thereof for the Mehrten Project, Delta-Mokelumne River Diversion Project, and for corresponding works of an intermediate capacity of 35 second-feet. From these curves the costs of pumping plants and conveyance systems at Clements and Lockeford for the Camanche Project were estimated.

Pertinent data with respect to general features of the proposed dam, reservoir, and hydroelectric power plant of the Camanche Project, as designed for cost estimating purposes, are presented in Table 48.

The capital cost of the Camanche Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be about $12,528,000. The corresponding annual costs were estimated to be about $600,000. The resultant estimated unit cost of the 12,000 acre-feet per season of new irrigation yield delivered to the Western Mokelumne Unit, and 40,000 acre-feet per season of new irrigation yield delivered to the Eastern Mokelumne Unit, was about $10.70 and $12.20 per acre-foot, respectively. On a 4 per cent interest basis the estimated unit cost of new irrigation yield per season to the Western and Eastern Mokelumne River Units was about $12.25 and $14.35 per acre-foot, respectively. The estimates of unit cost are subject to reduction in the amount of hydroelectric power revenues that might be assigned for payment of irrigation features of the project. Annual power revenues, on the basis of $22 per kilowatt of dependable power capacity and 2.8 mills per kilowatt-hour of energy output, would amount to about $105,000. If these revenues were credited to the project, estimated unit cost of the new irrigation yield to the Western and Eastern Mokelumne River Units would be about $8.70 and $10.20 per acre-foot, respectively, on a 3 per cent interest basis, and $10.25 and $12.35 per acre-foot, respectively, on a 4 per cent interest basis.

TABLE 48

GENERAL FEATURES OF CAMANCHE PROJECT *

Main Earthfill Dam
- Crest elevation—220 feet
- Crest length—1,600 feet
- Crest width—30 feet
- Height, spillway lip above stream bed—112 feet
- Side slopes—3:1 upstream
  2:1 downstream
- Freeboard, above spillway lip—18 feet
- Elevation of stream bed—90 feet
- Volume of fill—3,252,000 cubic yards

Auxiliary Saddle Dam
- Number of saddle dams—7
- Aggregate crest lengths—10,102 feet
- Crest widths—20 feet
- Side slopes—2.5:1
- Total volume of fill—1,260,000 cubic yards

Reservoir
- Surface area at spillway lip—5,340 acres
- Capacity at spillway lip—212,000 acre-feet
- Drainage area—625 square miles
- Estimated mean seasonal natural runoff—780,000 acre-feet
- Estimated seasonal new irrigation yield—52,000 acre-feet
- Type of spillway—Chute, with curved ogee weir, concrete-lined
- Spillway capacity—77,000 second-feet
- Type of outlet—10-foot diameter steel pipe, dividing into two 7-foot diameter steel pipes

Power Plant
- Penstock—7-foot diameter steel pipe
- Maximum capacity of penstock—600 second-feet
- Installed capacity—4,000 kilowatts
- Maximum operating head—100 feet

* Features for diversion and conveyance of new water to lands in Eastern Mokelumne Unit omitted.

Estimated capital and annual costs of the Camanche Project on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
Camanche Dam and Reservoir	$11,176,000	$461,000
Camanche Power Plant	872,000	80,000
Subtotals	$12,378,000	$560,000
Clements Diversion		
Pumping plant	$90,000	$26,500
Conveyance system	54,000	2,500
Subtotals	$144,000	$29,000
Lockeford Diversion		
Pumping plant	$66,000	$18,000
Conveyance system	270,000	12,000
Subtotals	$336,000	$30,000
TOTALS	$12,528,000	$600,000

Middle Bar Project

Construction of a dam and reservoir on the Mokelumne River at the Middle Bar site, with appropriate downstream diversion and conveyance facilities, would provide new water to meet a portion of the estimated present supplemental requirement in the Eastern Mokelumne Unit. Use of the new water supply would also reduce progressive lowering of the ground water levels in the areas served. In addition, a hydroelectric power plant could be constructed at the dam, with resultant revenue from the sale of electrical energy.

The Middle Bar site is located in Section 16, Township 5 North, Range 11 East, M. D. B. & M., about 5.5 miles upstream from the existing Pardee Dam. This plan is hereinafter referred to as the "Middle Bar Project," and its principal features are delineated on Plate 20, entitled "Middle Bar Project." The East Bay Municipal Utility District has made application to the State Engineer to appropriate Mokelumne River water by construction of a dam and reservoir at the Middle Bar site, and conveyance of the conserved water to the east San Francisco Bay area for municipal purposes.

The Middle Bar Dam would be a concrete gravity structure, with an overpour spillway in its center section. Stream bed elevation at the dam site is about 505 feet. Flood waters of the Mokelumne River, conserved by the reservoir and released on a demand schedule during the irrigation season, would pass through the hydroelectric power plant located at the base of the dam. The waters would then be available downstream for diversion and conveyance to service areas south and north of the Mokelumne River, by the Clements and Lockeford Diversions, respectively.

It was estimated that mean seasonal runoff of the Mokelumne River, from the 550 square miles of watershed above the Middle Bar dam site, is about 760,000 acre-feet. Based upon yield studies during the critical dry period which occurred from 1926-27 through 1934-35, together with topography of the dam site and cost analyses hereinafter discussed, a reservoir of 46,500 acre-foot storage capacity, with estimated new seasonal irrigation yield of about 11,000 acre-feet, was chosen for purposes of cost estimates to be presented in this bulletin. The yield study for this size of reservoir is included in Appendix K.

The yield of the Middle Bar Project was allocated equally to the two service areas for purposes of this study. Lands south of the Mokelumne River would be served 5,500 acre-feet of new water by the Clements Diversion. Percolation losses in the unlined canals and ditches were estimated to be 25 per cent, leaving some 4,100 acre-feet of water per season for application to irrigated lands. Assumed losses in the concrete-lined canals of the Lockeford Diversion were negligible. Therefore, the entire diversion of 5,500 acre-feet of water per season would be available for application to irrigated lands north of the river. The pumping plants and canals for the Clements and Lockeford Diversions were designed with capacities of 20 second-feet, based on the estimated maximum monthly diversion during July.

Based on a seasonal irrigation application of 3.0 acre-feet per acre, the new water supply could serve 1,400 acres and 1,800 acres south and north of the Mokelumne River, respectively. Furthermore, based on an estimated seasonal consumptive use of applied water of 1.6 acre-feet per acre, percolation of the unconsumed portion of applied irrigation water, plus canal percolation losses, would augment ground water supplies in the foregoing areas by some 2,300 acre-feet and 2,600 acre-feet, respectively.

A topographic survey of the Middle Bar reservoir site up to an elevation of 1,450 feet was made by the East Bay Municipal Utility District in 1951, utilizing photogrammetric methods. From the survey data a map was prepared at a scale of 1 inch equals 400 feet, and with a contour interval of 10 feet. Storage capacities of the Middle Bar Reservoir at various stages of water surface elevation, as derived from this map, are given in Table 49.

TABLE 49

AREAS AND CAPACITIES OF MIDDLE BAR RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	505	0	0
20	525	5	50
40	545	34	450
60	565	90	1,700
80	585	150	4,100
100	605	225	7,600
120	625	328	13,000
140	645	430	20,700
160	665	550	30,500
180	685	686	42,800
185	690	724	46,500
200	705	835	57,300

Based upon preliminary geological reconnaissance, the Middle Bar dam site is considered to be suitable for a concrete gravity dam up to a maximum height of more than 200 feet. An arch dam might also be considered at this site. Lack of a suitable supply of earthfill material in the area indicates that a concrete dam of some sort probably would be the most feasible. Aggregates for the structure could be obtained in adequate quantities locally from the channel of the Mokelumne River. This same type of material was successfully used in the construction of Pardee Dam.

In the vicinity of the dam site, the Mokelumne River has cut a narrow steep-walled gorge through a relatively hard and resistant zone of Jurassic metasediments and meta-volcanics. This zone appears to trend across the canyon and to dip steeply upstream. The canyon walls are often developed along joint planes which dip steeply toward the channel. Although rock exposed on the abutments is hard and durable, it is so strongly jointed that the surface exposures appear blocky. Sloughing of the jointed rock has resulted in the accumulation of some talus on the lower abutments, and probably also in the channel bottom. Since the construction of Pardee Dam, a depth of about 10 feet of silt is estimated to have collected in the reservoir created by that dam. Small sharp ravines and knife-edged ridges were noted on either abutment, with differential elevations of some 10 to 30 feet. The ridges represent harder ribs and the ravines softer, or possibly sheared or crushed, zones in the series. Stripping from the abutments normal to the surface should not exceed 1 foot of soil and 30 feet of broken blocky rock. Removal of about 10 feet of lake-deposited silt, plus 5 feet of fractured rock, should adequately prepare and shape the foundation in the channel section.

An overpour spillway could best be employed at this site, with moderate protection provided for the area where the nappe impinges. Because this structure would lie in the upper end of Pardee Reservoir, it seems probable that a tailwater cushion would frequently be available at the base of the spillway.

A bridge on State Highway 49 and a county bridge, both crossing the Mokelumne River, would be inundated by a reservoir of the chosen capacity at the Middle Bar site. In addition, one-half mile of the state highway, 2.5 miles of county road, and about 3.5 miles of the access road to the Electra Power Plant of the Pacific Gas and Electric Company would be inundated. Three groups of farm buildings are located in the reservoir area. Lands in the reservoir area are used mostly for grazing, and are of relatively poor quality.

As a result of yield studies, geologic reconnaissance, and preliminary economic analysis, a concrete gravity dam, 155 feet in height from stream bed to spillway lip, and with a crest elevation of 695 feet, was selected to illustrate estimates of costs of the Middle Bar Project. The dam would have a crest length of about 405 feet, a crest width of 30 feet, and 0.05 : 1 upstream and 0.8 : 1 downstream slopes. The volume of concrete in the dam would be an estimated 127,900 cubic yards.

The spillway would be a concrete overpour section, located in the center of the dam. The spillway would be provided with three taintor gates, each 30 feet high and 50 feet wide. The radius of each gate would be 34 feet. The elevation of the spillway lip would be 660 feet. With the gates closed, the top of the gate would be at an elevation of 690 feet. The maximum depth of water above the spillway lip would be 30 feet, and an additional 5 feet of freeboard would be provided. The spillway would have a capacity of 87,000 second-feet with the taintor gates fully opened, required for an assumed maximum discharge of 155 second-feet per square mile of drainage area. The spillway would discharge into the Mokelumne River at the downstream toe of the dam.

The outlet works would include two 5-foot diameter steel pipes, 900 feet in length, through the center of the dam. Water would be released through the two pipes at an elevation of approximately 600 feet, and would discharge from the dam at an elevation of about 575 feet. Two 4.5-foot by 4.5-foot high-pressure slide gates, hydraulically operated, would be provided in each outlet pipe near the upstream face of the dam. Access to the gates would be through a gate chamber provided in the dam.

A penstock, to divert water from the reservoir to a proposed power plant, would be located through the left abutment of the dam. The penstock would release water through the dam at an elevation of about 600 feet, and would be provided with an 18-foot by 18-foot Broome gate on the upstream face of the dam. The penstock would be steel-lined, 12 feet in diameter, and would have a maximum capacity of 1,300 second-feet. The length of the penstock would be 300 feet. The power plant would be located immediately downstream from the left abutment of the dam, and would operate under a maximum head of 115 feet. The installed power capacity of the plant would be 10,000 kilowatts, and it would operate on a load factor of 50 per cent. The dependable power capacity of the Middle Bar Power Plant would be about 6,000 kilowatts, and its average annual energy output would be about 48,400,000 kilowatt-hours. The power plant would be housed in a reinforced-concrete structure 80 feet in height, 70 feet in length, and 60 feet in width. Water released from the power plant would be returned to the Mokelumne River near the downstream toe of the dam.

New water from the Mokelumne River would be served to areas in the Eastern Mokelumne Unit north and south of the river by means of the Clements and Lockeford Diversions, which have been described in detail in a previous section pertaining to the Delta-Mokelumne River Diversion Project. The general features, locations of pumping plants, and routes of canals would be the same for the Middle Bar Project. Furthermore, the size of the features and cost thereof would be approximately the same as those for the Mehrten Project, descriptive data for which are presented in Table 45. For these reasons no detailed design of the similar diversion and conveyance features of the Middle Bar Project was made, it being assumed that the costs would be approximately the same as those estimated for the Mehrten Project.

Pertinent data with respect to general features of the proposed dam, reservoir, and hydroelectric power plant of the Middle Bar Project, as designed for cost estimating purposes, are presented in Table 50.

The capital cost of the proposed Middle Bar Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be about $6,995,000. The corresponding annual costs were estimated to be about $380,000. The resultant estimated unit cost of the 11,000 acre-feet per season of new irrigation yield served by the project was about $34.50 per acre-foot. On a 4 per cent interest basis the unit cost of new irrigation yield per season was about $39.80 per acre-foot. The estimates of unit cost are subject to reduction in the amount of the hydroelectric power revenues that might be assigned for payment of irrigation features of the project. Annual power revenues, on the basis of $22 per kilowatt of dependable power capacity and 2.8 mills per kilowatt-hour

Railroad Flat Dam Site, South Fork of Mokelumne River

TABLE 50

GENERAL FEATURES OF MIDDLE BAR PROJECT *

Concrete Gravity Dam
- Crest elevation—695 feet
- Crest length—405 feet
- Crest width—30 feet
- Height, spillway lip above stream bed—155 feet
- Side slopes—0.05:1 upstream
  0.8:1 downstream
- Freeboard, above spillway lip—35 feet
- Elevation of stream bed—505 feet
- Volume of fill—127,900 cubic yards

Reservoir
- Surface area at spillway lip—460 acres
- Surface area at top of gates—686 acres
- Capacity at spillway lip—28,000 acre-feet
- Capacity at top of gates—46,500 acre-feet
- Drainage area—550 square miles
- Estimated mean seasonal runoff—760,000 acre-feet
- Estimated seasonal new irrigation yield—11,000 acre-feet
- Type of spillway—Concrete overpour section
- Spillway capacity—87,000 second-feet
- Type of outlet—Two 5-foot diameter steel pipes

Power Plant
- Penstock—12-foot diameter steel-lined tunnel
- Maximum capacity of penstock—1,300 second-feet
- Installed capacity—10,000 kilowatts
- Maximum operating head—115 feet

* Features for diversion and conveyance of new water supply to lands in Eastern Mokelumne Unit omitted.

of energy output, would amount to about $268,000. If these revenues were credited to the project, the estimated unit cost of the new water supply would be about $10.20 per acre-foot on a 3 per cent interest basis, and $15.40 per acre-foot on a 4 per cent interest basis.

Estimated capital and annual costs of the Middle Bar Project on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
Middle Bar Dam and Reservoir	$4,876,000	$200,000
Middle Bar Power Plant	1,810,000	151,000
Subtotals	$6,686,000	$351,000
Clements Diversion		
Pumping plant	$36,000	$10,000
Conveyance system	47,000	2,000
Subtotals	$83,000	$12,000
Lockeford Diversion		
Pumping plant	$32,000	$8,000
Conveyance system	194,000	9,000
Subtotals	$226,000	$17,000
TOTALS	$6,995,000	$380,000

Railroad Flat Project

Construction of a dam and reservoir on the South Fork of the Mokelumne River at the Railroad Flat site, with appropriate downstream diversion and conveyance facilities, would provide new irrigation yield to meet some two-thirds of the estimated present supplemental water requirement in the Eastern Mokelumne Unit. Use of this new water supply would also reduce progressive lowering of ground water levels in the areas served. The Railroad Flat dam site is located in the northeast quarter of Section 23, Township 6 North, Range 13 East, M. D. B. & M., about 2,000 feet downstream from the mouth of the Licking Fork and 1.5 miles due north of the community of Railroad Flat. Provision would also be made for diversion of surplus flows of the Middle Fork of the Mokelumne River and their conveyance to Railroad Flat Reservoir. The plan is hereinafter referred to as the "Railroad Flat Project," and its principal features are delineated on Plate 21, entitled "Railroad Flat Project." The East Bay Municipal Utility District has made application to the State Engineer to appropriate Mokelumne River water by construction of a dam and reservoir at the Railroad Flat site, and conveyance of the conserved water to the east San Francisco Bay area for municipal purposes. The Calaveras County Water District also has made application at the Railroad Flat site, and proposes conveyance of the conserved water to areas of use in Calaveras County for irrigation and domestic purposes.

Consideration was given to the possible inclusion of a hydroelectric power plant immediately below Railroad Flat Dam for the purpose of generation of electrical energy. However, studies indicated that the feasible installed capacity, and net revenues resulting from sale of energy output, would be so small as not to warrant installation of a power plant at the dam. For these reasons no further consideration was given to inclusion of a power plant in the Railroad Flat Project.

The proposed Railroad Flat Dam would be an earthfill structure, with a chute-type spillway. Stream bed elevation at the dam site is about 2,130 feet. The proposed diversion weir on the Middle Fork of the Mokelumne River would consist of a concrete gravity overpour structure and apron, at a stream bed elevation of 2,740 feet, and would be located immediately downstream from the junction of the North Fork of the Middle Fork and the Middle Fork. The diverted water would be conveyed in a southwesterly direction in a canal, which would terminate at the Licking Fork, a tributary of the South Fork, at a point near Woodcock. Flood waters of the South and Middle Forks of the Mokelumne River, conserved by Railroad Flat and released on a demand schedule during the irrigation season, would be available downstream for diversion and conveyance to areas south and north of the Mokelumne River by the Clements and Lockeford Diversions, respectively.

It was estimated that mean seasonal runoff of the South Fork of the Mokelumne River, from its 66 square miles of watershed above the Railroad Flat dam site, is about 51,500 acre-feet. The proposed Middle Fork Diversion would convey 100 second-feet from the Middle Fork of the Mokelumne River into

Railroad Flat Reservoir, and would increase the mean seasonal runoff available at the dam site to about 76,500 acre-feet. Based upon yield studies during the critical dry period which occurred from 1928-29 through 1933-34, together with topography of the dam site and cost analyses hereinafter discussed, a reservoir of 80,000 acre-foot storage capacity, with estimated new seasonal irrigation yield of 20,000 acre-feet, was chosen for purposes of cost estimates to be presented in this bulletin. The yield study for this size of reservoir is included in Appendix K.

The yield of the Railroad Flat Project was allocated equally to the two service areas, for purposes of this study. Lands south of the Mokelumne River would be served 10,000 acre-feet of new water seasonally by the Clements Diversion. Percolation losses in the unlined canals were estimated to be 25 per cent, leaving some 7,500 acre-feet of water per season for application to irrigated lands. Losses in the concrete-lined canals of the Lockeford Diversion were assumed to be negligible. Therefore, the entire diversion of 10,000 acre-feet per season would be available for application to irrigated lands north of the river. The pumping plants and canals for the Clements and Lockeford Diversions were designed with capacities of 35 second-feet, based on the estimated maximum monthly diversion during July.

Based on an average seasonal irrigation application of 3.0 acre-feet per acre, the new water supply could be applied to about 2,500 acres and 3,300 acres south and north of the river, respectively. The seasonal consumptive use of applied irrigation water was estimated at 1.6 acre-feet per acre. Based on this value, percolation of unconsumed water applied to irrigated lands, plus percolation losses from unlined canals, would augment ground water supplies by 6,000 acre-feet and 5,400 acre-feet in the areas south and north of the Mokelumne River, respectively. The maximum elevations in the respective service areas are about 140 feet and 100 feet.

A topographic survey of the Railroad Flat reservoir site up to an elevation of 2,800 feet was made by the East Bay Municipal Utility District in 1951, and a map was drawn to a scale of 1 inch equals 400 feet, with a contour interval of 10 feet. Storage capacities of the Railroad Flat Reservoir at various stages of water surface elevation are given in Table 51.

Based upon preliminary geological reconnaissance, the Railroad Flat dam site is considered to be suitable for an earthfill dam of any height up to at least 350 feet. The foundation rock consists principally of slate and argillite of the Calaveras formation. The slates are often strongly jointed and moderately weathered. The argillites are platy and somewhat schistose in places. Both rocks show limy streaks along some bedding planes. Masses of limestone outcrop on the north

TABLE 51

AREAS AND CAPACITIES OF RAILROAD FLAT RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	2,130	0	0
20	2,150	5	10
40	2,170	10	100
60	2,190	27	400
80	2,210	60	1,200
100	2,230	95	2,900
120	2,250	127	5,000
140	2,270	160	8,000
160	2,290	195	11,700
180	2,310	237	16,000
200	2,330	278	21,000
220	2,350	325	27,000
240	2,370	377	33,800
260	2,390	434	42,300
280	2,410	494	51,100
300	2,430	557	62,000
320	2,450	640	74,000
329	2,459	678	80,000
340	2,470	725	88,000

canyon wall at and immediately upstream from the site. A large greenstone dike also cuts the slate on the right abutment. Rock of this dike is relatively hard, dense, moderately jointed, and only slightly weathered. Stripping on the abutments should not exceed seven feet of soil and weathered bedrock from under the earthen section of the dam. Five feet of gravel and boulders overlie bedrock in the channel section, and removal of three feet of bedrock beneath this fill would be necessary for shaping of the foundation under the impervious section of the dam. A number of abandoned mines in the left abutment of the dam site would require plugging to eliminate the possibility of leakage from the reservoir.

A spillway could best be cut around the end of the dam across the right abutment. This would provide an excellent path for direct discharge from the spillway along the line of the river course. The spillway cut would have to be lined throughout almost its entire length. Side cuts should stand on 1:1 slopes without danger of sliding.

Materials for the combination earth- and rockfill structure, which is presently planned for this site, are available within feasible haul distances. Earthfill for the impervious core is obtainable from a deep cover of decomposed granite which lies on hill slopes of the Middle Fork drainage, about two miles northwest of the site. Paved roads provide ready access to several potential borrow areas in this vicinity. Excellent rockfill material can be quarried from the banks of the South Fork of the Mokelumne River immediately downstream from the site.

The area which would be inundated by the dam consists for the most part of forested land, with some land devoted to grazing. Some minor relocation of power and telephone lines would be required. About two miles of the paved highway between Railroad Flat and West Point, as well as about one mile of dirt road, would be inundated. A number of ranch homes and buildings lie within the reservoir area.

As a result of yield studies, geologic reconnaissance, and preliminary economic analysis, an earthfill dam, 329 feet in height from stream bed to spillway lip, and with a crest elevation of 2,469 feet, was selected to illustrate estimates of cost of the Railroad Flat Project. The dam would have a crest length of about 1,060 feet, a crest width of 30 feet, and 2.5:1 upstream and downstream slopes. The central impervious core would have a top width of 10 feet and 0.8:1 slopes. A 20-foot filter would blanket both the upstream and downstream slopes of the impervious section. The outer pervious zones of the dam would consist of quarried rock. The upstream face of the dam would be blanketed with derrick-placed rock. The volume of fill would be an estimated 4,667,000 cubic yards.

The spillway would be of the chute type, located across the right abutment. The control structure would consist of a curved ogee weir, followed by a concrete-lined chute about 1,150 feet in length. The maximum depth of water above the spillway lip would be 6 feet, and an additional 4 feet of freeboard would be provided. The spillway would have a capacity of 12,000 second-feet, required for an assumed maximum discharge of 180 second-feet per square mile of drainage area. The spillway would discharge into the main channel about 500 feet downstream from the toe of the dam.

The outlet works would include a circular pressure tunnel, 8 feet in diameter and 2,500 feet in length, excavated through the left abutment and concrete-lined. The tunnel would be used to divert flow of the river during the construction period. After completion of the dam a concrete plug would be placed in the tunnel about 500 feet from its lower end, and a 4-foot by 4-foot high-pressure slide gate would be installed to control releases of water from the reservoir. A 48-inch diameter steel pipe, with capacity of 380 second-feet, would convey the water through the lower 500 feet of the tunnel, and would terminate in a 48-inch diameter Howell-Bunger valve, at the lower tunnel portal.

The diversion dam on the Middle Fork of the Mokelumne River, to divert flow of the Middle Fork to the South Fork, would consist of a concrete gravity overpour section and apron, 10 feet in height above stream bed and some 60 feet in length. Headworks would be provided at the left abutment of the structure to control the flow into the conveyance canal. The headworks would consist of a 17-foot by 40-foot reinforced-concrete structure, 15 feet in height, provided with three 4-foot by 5-foot slide headgates. The headworks would also be provided with two 4-foot diameter slide sluice gates to waste entrapped sand and silt.

The diverted water would be conveyed in a southwesterly direction in a concrete-lined canal of 100 second-foot capacity a distance of about 11,000 feet. The canal would be shotcrete-lined, and of trapezoidal section, with 1:1 side slopes, bottom width of 3.0 feet, depth of 3.8 feet, freeboard of 1.0 foot, and slope of 9.8 feet per mile. The velocity of flow in the canal would be about 6.0 feet per second.

The Clements and Lockeford Diversions, which would serve new water from the Mokelumne River to areas in the Eastern Mokelumne Unit south and north of the river have been described in detail in a previous section pertaining to the Delta-Mokelumne Diversion Project. The general features, locations of pumping plants, and routes of canals would be the same for the Railroad Flat Project. Furthermore, the size of the features and cost thereof would lie between those estimated for the Delta-Mokelumne Diversion Project and for the Mehrten Project. Curves were prepared relating capacities of the pumping plants and conveyance systems to costs thereof for these two projects, and for corresponding features with an intermediate capacity of 35 second-feet. From these curves the costs of pumping plants and conveyance systems for the Railroad Flat Project were estimated.

Pertinent data with respect to general features of the proposed Railroad Flat Dam and Reservoir, and facilities for diversion of flow thereto from the Middle Fork of the Mokelumne River, as designed for cost estimating purposes, are presented in Table 52.

TABLE 52

GENERAL FEATURES OF RAILROAD FLAT PROJECT *

Earthfill Dam
- Crest elevation—2,469 feet
- Crest length—1,060 feet
- Crest width—30 feet
- Height, spillway lip above stream bed—329 feet
- Slide slopes—2.5:1
- Freeboard, above spillway lip—10 feet
- Elevation of stream bed—2,130 feet
- Volume of fill—4,667,000 cubic yards

Reservoir
- Surface area at spillway lip—678 acres
- Capacity at spillway lip—80,000 acre-feet
- Drainage area—66 square miles
- Estimated available mean seasonal runoff—76,500 acre-feet
- Estimated seasonal new irrigation yield—20,000 acre-feet
- Type of spillway—Chute, concrete-lined
- Spillway capacity—12,000 second-feet
- Type of outlet—8-foot diameter pressure tunnel and 48-inch diameter steel pipe through left abutment

Middle Fork Diversion Conduit
- Type—Trapezoidal, shotcrete-lined canal
- Length, in miles—2.1
- Side slopes—1:1
- Bottom width—3.0 feet
- Depth—3.8 feet
- Freeboard—1.0 foot
- Slope—9.8 feet per mile
- Velocity—6.0 feet per second
- Capacity—100 second-feet

* Features for diversion and conveyance of new water to lands in Eastern Mokelumne Unit omitted.

The capital cost of the Railroad Flat Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be $14,178,000. The corresponding annual costs were estimated to be about $594,000. The resultant estimated average unit cost of the 20,000 acre-feet per season of new irrigation yield from Railroad Flat Reservoir was about $29.70 per acre-foot. On a 4 per cent interest basis the unit cost of new irrigation yield per season was about $35.10 per acre-foot.

Estimated capital and annual costs of the Railroad Flat Project on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
Railroad Flat Dam and Reservoir	$13,656,000	$551,000
Middle Fork Diversion	179,000	8,000
Subtotals	$13,835,000	$559,000
Clements Diversion		
Pumping plant	$47,000	$13,000
Conveyance system	48,000	2,000
Subtotals	$95,000	$15,000
Lockeford Diversion		
Pumping plant	$39,000	$10,000
Conveyance system	209,000	10,000
Subtotals	$248,000	$20,000
TOTALS	$14,178,000	$594,000

Ione Project

Construction of a dam and reservoir on Dry Creek at the Ione site would provide new irrigation yield to meet the present supplemental water requirement of the portion of the Eastern Mokelumne Unit lying north of the Mokelumne River, and for growth in water utilization for a number of years into the future. Use of the new water supply would also prevent progressive lowering of ground water levels in the areas served. The Ione site is located in Section 13, Township 5 North, Range 8 East, M. D. B. & M., about 7.5 miles southwest of Ione, and one mile west of the San Joaquin-Amador county line. In addition to the dam and reservoir, there would also be included facilities for conveyance of the conserved water to lands south of Dry Creek and north of the Mokelumne River in the Eastern Mokelumne Unit. The proposed Ione Dam would be an earthfill structure with a chute-type spillway. Stream bed elevation at the dam site is about 160 feet. Flood waters of Dry Creek, conserved by the reservoir and released on a demand schedule during the irrigation season, would be conveyed in a canal to a point about two miles northwest of Clements to serve an area lying between Dry Creek and the Mokelumne River, just north of Lockeford. This plan is hereinafter referred to as the "Ione Project," and its principal features are delineated on Plate 22, entitled "Ione Project."

It was estimated that mean seasonal runoff of Dry Creek, from the 274 square miles of watershed above the dam site, is about 99,000 acre-feet. Based upon yield studies during the critical dry period which occurred from 1927-28 through 1934-35, together with topography of the dam site, and cost analyses hereinafter discussed, a reservoir of 40,000 acre-foot storage capacity, with estimated new seasonal irrigation yield of 21,000 acre-feet, was chosen for purposes of cost estimates to be presented in this bulletin. It was considered that present percolation of water in Dry Creek would continue under project operation from reservoir spill. Therefore, the irrigation yield of 21,000 acre-feet per season was assumed to be a new water supply. The yield study for this size of reservoir is included in Appendix K.

It was estimated that losses in conveyance and distribution of the 21,000 acre-feet per season of new irrigation yield, in the unlined canals of the Dry Creek-Clements Conduit, would be about 25 per cent, leaving some 15,800 acre-feet for application to irrigated lands. Based on a seasonal irrigation application of 3.0 acre-feet per acre, the new water supply could serve 5,300 acres. Furthermore, based on an estimated seasonal consumptive use of applied water of about 1.6 acre-feet per acre, percolation of the unconsumed portion of applied irrigation water, plus canal percolation losses, would augment ground water supplies by some 12,500 acre-feet per season. Maximum elevation in the service area is about 125 feet.

An estimate of the monthly distribution of demand for irrigation water obtained from ground water in the San Joaquin Area was presented in Table 39. Based on these data, it was estimated that the maximum monthly diversions for the service area would occur in July, and would amount to about 22 per cent of the total seasonal diversion of 21,000 acre-feet, equivalent to a continuous flow of about 75 second-feet throughout the month.

A topographic survey of the Ione reservoir site up to an elevation of 230 feet was made by the United States Bureau of Reclamation in 1946, and a map was drawn to a scale of 1 inch equals 200 feet, with a contour interval of 5 feet. Storage capacities of the Ione Reservoir at various stages of water surface elevation, as derived from this map, are given in Table 53.

Based upon preliminary geological reconnaissance, the Ione dam site is considered to be suitable for an earthfill dam of any height up to a maximum of about 150 feet. The foundation bedrock consists of a series of nearly horizontal, well-bedded sediments. These are primarily tuffaceous sandstones, interbedded with some conglomerate and with occasional siliceous shales, which are part of the Ione formation of Eocene age. Much of the exposed rock is friable and thoroughly weathered, although some relatively unweathered material, occurring chiefly in the conglomerate and shale interbeds, also outcrops. A man-

TABLE 53

AREAS AND CAPACITIES OF IONE RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	160	100	0
5	165	200	1,000
10	170	330	3,000
15	175	500	5,500
20	180	740	9,500
25	185	1,020	14,000
30	190	1,400	20,000
35	195	1,900	29,000
40	200	2,420	40,000
45	205	3,000	55,000
50	210	3,720	75,000

tle of red clay, containing a high percentage of pebbles and cobbles, covers the hill slopes surrounding the site. This material probably represents the Arroyo Seco formation of Pleistocene age. Structural features are not of primary importance at this site. Stripping should not exceed five feet on the abutments, but drill hole records indicate an average depth of about 20 feet of Recent gravels, sands, and clays across the bottom of the stream bed.

A spillway could be placed around either end of the dam, or through any of several saddles to the north, depending upon the height of the structure. In any of these locations the entire spillway channel would have to be lined to prevent undue erosion of the soft underlying sediments.

Adequate supplies of earth suitable for use in an impervious fill can be obtained upstream within the reservoir area. The average haul distance would be about two miles. Other required construction materials are located within feasible hauling distances of the site.

About 10 homes and groups of farm buildings would be inundated by a reservoir of the chosen capacity at the Ione site. In addition, about two miles of State Highway 88, including three major bridges, and approximately 10 miles of surfaced county road, would require relocation. Lands within the reservoir area include some 300 acres of potentially highly productive bottom land, and 2,000 acres of rolling grazing land.

As a result of yield studies, geologic reconnaissance, and preliminary economic analysis, an earthfill dam, 40 feet in height from stream bed to spillway lip, and with a crest elevation of 215 feet, was selected to illustrate estimates of cost of the Ione Project. The dam would have a crest length of about 1,630 feet, a crest width of 30 feet, and 2.5:1 upstream and 2:1 downstream slopes. The central impervious core would have a top width of 10 feet and 1:1 slopes. The outer pervious zones of the dam would consist of materials salvaged from excavation for the impervious core. The upstream slope of the dam would be faced with 5 feet of riprap. The volume of fill would be an estimated 598,000 cubic yards.

The spillway would be of the chute type, located across the right abutment. The control structure would consist of a curved ogee weir, and would be followed by a discharge channel, concrete-lined for a distance of about 400 feet. The elevation of the spillway lip would be 200 feet. The maximum depth of water above the spillway lip would be 10 feet, and an additional 5 feet of freeboard would be provided. The spillway would have a capacity of 42,000 second-feet, required for an assumed discharge of 154 second-feet per square mile of drainage area. The spillway would discharge into Dry Creek about 1,500 feet below the downstream toe of the dam.

The outlet works would consist of a 48-inch diameter steel pipe, placed in a trench excavated beneath the dam and encased in concrete. Releases of water from the reservoir would be controlled at the upstream end by a 4-foot by 4-foot slide gate operated from the crest of the dam. The outlet would be controlled at the downstream end by a 36-inch diameter Howell-Bunger valve, and the water would be released into a stilling basin, from which it could either enter the conveyance canal, or spill through a wasteway into the Dry Creek channel. The stilling basin would be a reinforced-concrete structure 10 feet in width, 40 feet in length, and 7 feet in height. The elevation of the bottom of the stilling basin would be about 161 feet. Flow from the stilling basin to the canal would be controlled by a 5-foot by 3.5-foot slide headgate set in a headwall. Excess water in the stilling basin would discharge over a weir to return to Dry Creek downstream from the dam. The length of the weir would be 10 feet, and its crest elevation 165 feet.

The proposed Dry Creek-Clements Conduit, with a capacity of 85 second-feet, would extend from Ione Dam in a southwesterly direction a distance of approximately 12.5 miles to a point about two miles northwest of Clements. It would include a shotcrete-lined canal for an initial distance of 7.7 miles, which would be of trapezoidal section, with 1.5:1 side slopes, bottom width of 4.0 feet, depth of 4.4 feet, and freeboard of 1.0 foot. Its slope would be approximately 1.7 feet per mile, and the velocity would be about 2.7 feet per second. It would follow the south bank of Dry Creek for about five miles, then turn south for a distance of about 2.5 miles to a crossing of Goose Creek at an elevation of 151 feet. The crossing at Goose Creek would be accomplished by means of an inverted siphon some 2,000 feet in length, consisting of a 42-inch diameter steel pipe placed in a trench beneath the channel. The siphon would discharge into an unlined canal of trapezoidal section, with 2:1 side slopes, bottom width of 5.0 feet, depth of 4.6 feet, and freeboard of 1.0 foot. Its slope would be approximately 1.8 feet per mile, and the velocity would be about 2.0 feet per second.

This canal would convey the water in a southerly direction for the remaining 4.5 miles to a terminus some two miles northeast of Clements at an elevation of approximately 140 feet.

Pertinent data with respect to general features of the Ione Project, as designed for cost estimating purposes, are presented in Table 54.

TABLE 54

GENERAL FEATURES OF IONE PROJECT

Earthfill Dam
- Crest elevation—215 feet
- Crest length—1,630 feet
- Crest width—30 feet
- Height, spillway lip above stream bed—40 feet
- Side slopes—2.5:1 upstream
  2:1 downstream
- Freeboard, above spillway lip—15 feet
- Elevation of stream bed—160 feet
- Volume of fill—598,000 cubic yards

Reservoir
- Surface area at spillway lip—2,420 acres
- Capacity at spillway lip—40,000 acre-feet
- Drainage area—274 square miles
- Estimated mean seasonal runoff—99,000 acre-feet
- Estimated seasonal new irrigation yield—21,000 acre-feet
- Type of spillway—Chute, concrete-lined
- Spillway capacity—42,000 second-feet
- Type of outlet—48-inch diameter steel pipe beneath dam

Dry Creek-Clements Conduit

Type	Trapezoidal, shotcrete-lined canal	Trapezoidal, unlined canal
Length, in miles	7.7	4.5
Side slopes	1.5:1	2:1
Bottom width, in feet	4.0	5.0
Depth, in feet	4.4	4.6
Freeboard, in feet	1.0	1.0
Slope, in feet per mile	1.7	1.8
Velocity, in feet per second	2.7	2.0
Capacity, in second-feet	85	85
Inverted siphon—42-inch diameter steel pipe, 2,000 feet in length.		

The capital cost of the Ione Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be $2,844,000. The corresponding annual costs were estimated to be about $122,000. The resultant estimated unit cost of the 21,000 acre-feet per season of new irrigation yield from the project was about $5.80 per acre-foot. On a 4 per cent interest basis, the unit cost of new water supply per season was about $7.20 per acre-foot.

Estimated capital and annual costs of the Ione Project on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
Ione Dam and Reservoir	$2,205,000	$94,000
Dry Creek-Clements Conduit	639,000	28,000
TOTALS	$2,844,000	$122,000

As an alternative to the foregoing plan, preliminary consideration was given to construction of a larger dam and reservoir at the Ione site, to store and develop the waters of Dry Creek and spill from the Mokelumne River at Pardee Dam. This alternative project would provide new irrigation yield to meet the present supplemental water requirement in the Eastern Mokelumne Unit, and for growth in water utilization for a number of years in the future.

The alternative project would include the construction of an earthfill dam and reservoir of 250,000 acre-foot storage capacity at the Ione site, and facilities for the conveyance of the conserved waters to lands north and south of the Mokelumne River in the Eastern Mokelumne Unit. Floodwaters of Dry Creek, and spill through the Jackson Creek spillway of Pardee Dam, with maximum discharge capacity of 16,000 second-feet, would be conserved by the reservoir. Based upon yield studies during the critical dry period which occurred from 1927-28 through 1934-35, the estimated new irrigation yield made available by the project would be about 74,000 acre-feet per season.

The conserved waters would be conveyed in an enlarged Dry Creek-Clements Conduit of 300 second-foot capacity, which would extend to the Mokelumne River to a terminus near Clements at an elevation of approximately 135 feet. Lands north of the Mokelumne River in the Eastern Mokelumne Unit would be served from this conduit. New water required in the area lying south of the Mokelumne River, in the Eastern Mokelumne Unit, would be released to the Mokelumne River from the conduit and rediverted by a pumping plant at the Clements Diversion. The water would then be conveyed to the service area by means of a canal extending southerly to and discharging into Bear Creek, from which creek the water could be pumped by existing and new pumps to serve lands lying adjacent to the creek. The capacity of the pumping plant and conveyance canal would be 150 second-feet.

Preliminary estimates of costs of the alternative project, on a 3 per cent interest basis, indicated that capital costs to deliver 74,000 acre-feet of water seasonally to the Eastern Mokelumne Unit would be about $6,660,000, and that annual costs would be about $345,000. The estimated average annual unit cost of the new yield delivered to service areas would be about $4.70 per acre-foot.

Irish Hill Project

Construction of a dam and reservoir on Dry Creek at the Irish Hill site, together with a diversion from Sutter Creek, would provide new irrigation yield to meet the present supplemental requirement of the portion of the Eastern Mokelumne Unit lying north of the Mokelumne River, and for growth in water utilization in that area for a number of years into the future. Use of the new surface supply would also prevent progressive lowering of ground water levels in the area served. The Irish Hill site is located in Section 1, Township 6 North, Range 9 East, M. D. B. & M., about 5.5 miles downstream from State Highway 49. The project would also include a diversion from Dry Creek and facilities for conveyance of the conserved water to and its distribution in the portion of the Eastern Mokelumne Unit lying north of the Mokelumne River. The plan is hereinafter referred to as the "Irish Hill Project," and its principal features are delineated on Plate 23, entitled "Irish Hill Project."

The proposed Irish Hill Dam would be an earthfill structure, with a chute-type spillway. Stream bed elevation at the dam site is about 400 feet. The diversion weir on Sutter Creek would replace an older structure which serves an existing ditch to Jackass Creek, and would consist of a concrete gravity overpour structure located about 0.6 mile downstream from the community of Sutter Creek. The diverted water would be conveyed about 3.0 miles in a westerly direction by flume, siphon, and canal to Horse Creek, tributary to Irish Hill Reservoir. Floodwaters of Dry and Sutter Creeks, conserved by Irish Hill Reservoir and released on a demand schedule during the irrigation season, would be diverted from Dry Creek in the northeast quarter of Section 13, Township 5 North, Range 8 East, M. D. B. & M., and conveyed by canal in a southwesterly direction for a distance of about 12.2 miles to the service area.

It was estimated that the mean seasonal runoff of Dry Creek, from its 77 square miles of watershed above the Irish Hill dam site, is about 34,000 acre-feet. The proposed Sutter Creek Diversion would convey 200 second-feet from Sutter Creek into the Irish Hill Reservoir, and would increase the mean seasonal runoff available at the dam site to about 53,000 acre-feet. Based upon yield studies during the critical dry period which occurred from 1926-27 through 1934-35, together with topography of the dam site and cost analyses hereinafter discussed, a reservoir of 43,500 acre-foot storage capacity, with estimated new seasonal irrigation yield of 20,000 acre-feet, was chosen for purposes of cost estimates to be presented in this bulletin. It was considered that present mean percolation of water in Dry Creek would continue under the project. Therefore, the irrigation yield of 20,000 acre-feet per season was assumed to be a new water supply. The yield study for this size of reservoir is included in Appendix K.

It was estimated that losses of water in conveyance and distribution of the 20,000 acre-feet per season of new irrigation yield assigned to the service area north of the Mokelumne River, in the unlined canals of the Dry Creek-Clements Diversion, would be about 25 per cent, leaving some 15,000 acre-feet of water for application to irrigated lands. Based on a seasonal irrigation application of 3.0 acre-feet per acre, the new water supply could serve 5,000 acres. It was estimated that seasonal consumptive use of applied water amounts to about 1.6 acre-feet per acre. On this basis, the unconsumed portion of applied irrigation water, plus canal percolation losses, would augment ground water supplies by some 12,000 acre-feet per season. The maximum elevation in the service area to be served is about 125 feet.

The design capacity of the Dry Creek-Clements Diversion was based on the maximum monthly irrigation diversion in the San Joaquin Area, which occurs in July. This monthly demand would be equivalent to a continuous flow of about 70 second-feet. The capacity of the diversion was increased to 85 second-feet to provide for shorter-term peaking.

Detailed dam and reservoir site topography, to an elevation of 520 feet, was obtained by the Division of Water Resources from a plane table survey made in 1947. This was supplemented by interpolation up to an elevation of 550 feet, from the United States Geological Survey Sutter Creek Quadrangle, at a scale of 1:62,500 and with a contour interval of 50 feet. The resulting map, prepared by the Division of Water Resources, was drawn to a scale of 200 feet to the inch, with a contour interval of 10 feet. Storage capacities of the Irish Hill Reservoir at various stages of water surface elevation are given in Table 55.

TABLE 55

AREAS AND CAPACITIES OF IRISH HILL RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	400	0	0
20	420	8	90
40	440	40	500
60	460	125	2,100
80	480	287	6,100
100	500	535	14,300
120	520	835	27,800
136	536	1,110	43,500
140	540	1,175	47,900

Based upon preliminary geological reconnaissance, the Irish Hill dam site is considered to be suitable for an earthfill dam of any height up to at least 200 feet. Bedrock locally consists of a series of metamorphic rock, ranging from schists to greenstones, with the latter type predominant. These represent a part of the Mariposa formation of Upper Jurassic age. This formation locally lies in a narrow belt, trending slightly west of north, where it has been upended along the western edge of the Sierra Nevada mountain block. Parting and fissility are often quite pronounced, and the beds invariably stand nearly vertically along the regional strike. Consequently, the scattered outcrops are often very prominent and craggy. Jointing is secondary to developed schistosity and parting.

Stripping beneath the impervious section of the main dam would average about 8 feet on the right abutment, including 5 feet of overburden and 3 feet of bedrock, and on the left abutment about 4 feet of overburden and 3 feet of bedrock. In the stream channel, about 10 feet of silt and 2 feet of bedrock should be excavated prior to placement of embankment. It is indicated that the spillway excavation will require blasting generally below 8-foot depths. Cuts in overburden would stand on slopes of about 1:1, but would require protective lining where subjected to flows of high velocity.

None of the materials from excavation operations, excepting perhaps rock from the spillway, is considered suitable for use as pervious fill or riprap. The principal source of pervious material would be from deposits of dredger tailings in the stream channel downstream. Impervious borrow is obtainable within a 2.5-mile radius of the site, from thin coatings of overburden on uneven land upstream or to the west, or within a slightly greater distance from the floor of Ione Valley to the southeast.

The area which would be inundated by the dam consists for the most part of grazing land. Few improvements exist within the reservoir area. About two miles of State Highway 104 would be inundated.

As a result of yield studies, geologic reconnaissance, and preliminary economic analysis, an earthfill dam, 136 feet in height from stream bed to spillway lip, and with a crest elevation of 550 feet, was selected to illustrate estimates of cost of the Irish Hill Project The dam would have a crest length of 1,050 feet, a crest width of 30 feet, and 2.5:1 upstream and downstream slopes. The central impervious core would have a top width of 10 feet and side slopes of 0.8:1. A required saddle dam, about 0.5 mile southerly from the left abutment of the main dam, would have a crest length of about 440 feet and a maximum height of about 30 feet. The saddle dam would be constructed entirely of impervious materials, and would have a top width of 20 feet and side slopes of 2.5:1. The upstream slope of the main dam and both slopes of the saddle dam would be protected with selected cobbles or riprap. The total volume of fill in the main dam and the saddle dam would be about 820,000 cubic yards.

The spillway would be of the chute type, located in a cut through the left abutment of the main dam. The control structure would consist of a curved ogee weir, 200 feet in length. From the weir, the sides of the spillway would converge gradually to a width of about 100 feet in a distance of 300 feet. Lining would be continued for a distance of 400 feet to a point where the spillway cut would intersect a natural ravine leading back into Dry Creek below the dam. The maximum depth of water above the spillway lip would be 10 feet, and an additional 4 feet of freeboard would be provided. The spillway would have a capacity of 22,000 second-feet, required for an assumed maximum discharge of 290 second-feet per square mile of drainage area.

The outlet works would consist of a 48-inch diameter steel pipe, 760 feet in length, encased in concrete under the left abutment of the dam. Suitable cutoff fins would be cast in the concrete encasement, and settlement would be avoided by founding the outlet in a trench on bedrock. Flow into the outlet would be through a twin 36-inch diameter manifold, protected by trash racks and equipped with hydraulically operated butterfly emergency gates. Releases would be regulated at the downstream end of the outlet by a 48-inch diameter Howell-Bunger valve. The outlet would have a discharging capacity of 100 second-feet under a 5-foot head. With the aid of relatively low cofferdams the outlet would be utilized for diverting stream flow during construction of the dam.

The diversion dam on Sutter Creek, to divert flow of Sutter Creek to Dry Creek, would consist of a concrete gravity overpour section, 6 feet in height above the stream bed elevation of 1,071 feet, and some 100 feet in length. Headworks would be provided at the right abutment of the structure to control diversions. The headworks would consist of a 10-foot by 40-foot reinforced-concrete box, 10 feet in height, provided with two 4-foot by 4-foot slide headgates. The headworks would also be provided with a 2-foot by 2-foot slide sluice gate to waste entrapped sand and silt.

The diverted water would be conveyed in a westerly direction in a Lennon type flume of 200 second-foot capacity a distance of about 1.6 miles. The flume would have a diameter of 99 inches and a slope of 10.5 feet per mile, and the velocity of flow would be 8.7 feet per second. From the flume the water would flow through about 0.6 mile of lined canal, a 308-foot length of 60-inch diameter steel pipe inverted siphon, another 0.1 mile of lined canal, and 375 feet of 60-inch diameter steel pipe in a cut and cover section, discharging into Jackass Creek at an elevation of 1,029 feet. The water would be rediverted from Jackass Creek about 0.5 mile downstream at an elevation of about 1,000 feet. From the small reinforced-concrete diversion weir, the water would flow northerly in a lined canal for about 0.6 mile to discharge into a tributary of Horse Creek above Irish Hill Reservoir. This last section would include a steel pipe inverted siphon crossing of Mule Creek. The siphon would be 325 feet in length and 60 inches in diameter. The canal sections would be shotcrete-lined and of trapezoidal section, with 1:1 side slopes, bottom width of 5.0 feet, depth of 5.0 feet, freeboard of 1.0 foot and slope of 6.0 feet per mile. The velocity of flow in the canals would be about 5.6 feet per second.

The proposed diversion weir on Dry Creek would consist of a concrete gravity overpour section with a crest elevation of 166 feet, and concrete aprons 50 feet and 15 feet upstream and downstream from the overpour section, respectively. At the end of the upstream apron a 30-foot impervious fill and cutoff wall would be provided. The gravity overpour section would be 6 feet in height above stream bed, and some 1,200 feet in length. A sluiceway 10 feet in width, and provided with movable flashboards, would be provided through the gravity section of the weir. The elevation at the bottom of the sluiceway would be 160 feet.

The conveyance canal, with a capacity of 85 second-feet, would extend from the point of diversion in a southwesterly direction a distance of about 12.5 miles to a point about two miles northwest of Clements. The headworks of the canal would be located in the left abutment of the diversion weir, and would consist of a reinforced-concrete headwall 12 feet in height, provided with a 4-foot by 5-foot slide headgate. The canal would be shotcrete-lined for a distance of 7.7 miles, and would be of trapezoidal section, with 1.5:1 side slopes, bottom width of 4.0 feet, depth of 4.4 feet, and freeboard of 1.0 foot. Its slope would be approximately 1.7 feet per mile, and the velocity would be about 2.7 feet per second. It would follow the south bank of Dry Creek for about five miles, then turn south for a distance of about 2.5 miles, to a crossing at Goose Creek at an elevation of 151 feet. The crossing of Goose Creek would be accomplished by means of an inverted siphon some 2,000 feet in length, consisting of a 42-inch diameter steel pipe placed in a trench beneath the channel. The siphon would discharge into an unlined canal of trapezoidal section, with 2:1 side slopes, bottom width of 5.0 feet, depth of 4.6 feet, and freeboard of 1.0 foot. Its slope would be approximately 1.8 feet per mile, and the velocity would be about 2.0 feet per second. This canal would convey the water in a southerly direction for the remaining 4.5 miles to a terminus two miles northeast of Clements, where the elevation would be approximately 140 feet.

Pertinent data with respect to general features of the Irish Hill Project, as designed for cost estimating purposes, are presented in Table 56.

The capital cost of the Irish Hill Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be $3,844,000. Corresponding annual costs were estimated to be about $167,000. The resultant estimated average unit cost of the 20,000 acre-feet per season of new irrigation yield from the Irish Hill Project was about $8.35 per acre-foot. On a 4 per cent interest basis, the unit cost of new water supply per season was about $9.80 per acre-foot.

TABLE 56

GENERAL FEATURES OF IRISH HILL PROJECT

Main Earthfill Dam
- Crest elevation—550 feet
- Crest length—1,050 feet
- Crest width—30 feet
- Height, spillway lip above stream bed—136 feet
- Side slopes—2.5:1
- Freeboard, above spillway lip—14 feet
- Elevation of stream bed—400 feet
- Volume of fill—780,000 cubic yards

Auxiliary Saddle Dam
- Crest length—440 feet
- Crest width—20 feet
- Side slopes—2.5:1
- Maximum height—30 feet
- Volume of fill—40,000 cubic yards

Reservoir
- Surface area at spillway lip—1,110 acres
- Capacity at spillway lip—43,500 acre-feet
- Drainage area—77 square miles natural tributary plus 54 square miles diverted
- Estimated mean seasonal runoff—53,000 acre-feet (including diverted flow of Sutter Creek)
- Estimated seasonal new irrigation yield—20,000 acre-feet
- Type of spillway—Lined chute with ogee weir control
- Spillway capacity—22,000 second-feet
- Type of outlet—48-inch diameter steel pipe beneath dam

Sutter Creek-Dry Creek Diversion
- Diversion Works—Concrete gravity weir, with overpour section, approximately 100 feet in length, and approximately 6 feet high above stream bed elevation of about 1,071 feet; reinforced-concrete headworks provided with two 4-foot by 4-foot slide headgates and a 2-foot by 2-foot sluice gate

Conveyance Conduits
- Type—Trapezoidal, shotcrete-lined canal in three sections
- Total length—1.3 miles
- Side slopes—1:1
- Bottom width—5 feet
- Depth—5 feet
- Freeboard—1.0 foot
- Slope—6.3 feet per mile
- Velocity—5.5 feet per second
- Capacity—200 second-feet

Conveyance Conduits—continued
- Type—Lennon-type flume
- Length—1.6 miles
- Diameter—99 inches
- Slope—10.5 feet per mile
- Velocity—8.7 feet per second
- Capacity—200 second-feet

Siphons
- Type—Inverted welded steel pipe in two sections
- Total length—633 feet
- Diameter—60 inches
- Velocity—10.2 feet per second
- Capacity—200 second-feet

Cut and Cover Section
- Type—Welded steel pipe
- Length—375 feet
- Diameter—60 inches
- Velocity—10.2 feet per second
- Capacity—200 second-feet

Dry Creek-Clements Diversion
- Diversion Works—Concrete gravity weir, with overpour section and concrete aprons upstream and downstream, approximately 1,200 feet in length, and approximately 6 feet high above stream bed elevation of about 160 feet; reinforced-concrete headworks provided with one 4-foot by 5-foot slide headgate

Conveyance Conduit

Type	Trapezoidal, shotcrete-lined canal	Trapezoidal, unlined canal
Length, in miles	7.7	4.5
Side slopes	1.5:1	2:1
Bottom width, in feet	4.0	5.0
Depth, in feet	4.4	4.6
Freeboard, in feet	1.0	1.0
Slope, in feet per mile	1.7	1.8
Velocity, in feet per second	2.7	2.0
Capacity, in second-feet	85	85

Inverted siphon—42-inch diameter steel pipe, 2,000 feet in length

(Courtesy of Stockton Chamber of Commerce)

Typical Delta Lands Near Stockton

Estimated capital and annual costs of the Irish Hill Project on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
Irish Hill Dam and Reservoir	$2,159,000	$92,000
Sutter Creek Diversion	538,000	24,000
Dry Creek-Clements Diversion	1,147,000	51,000
TOTALS	$3,844,000	$167,000

Delta-Stockton Diversion Project

A supplemental water supply for the City of Stockton and environs, in the Calaveras and Western Mokelumne Units, could be secured by a pumped diversion of water from the Sacramento-San Joaquin Delta. A satisfactory site for such a diversion exists near the junction of the Stockton Deep Water Channel and Turner Cut, about 9 miles northwest of the City Hall of Stockton. Water available in the Sacramento-San Joaquin Delta, over and above requirements of the Central Valley Project and other established rights and commitments, would be insufficient to meet requirements in the Calaveras and Western Mokelumne Units in some months during the irrigation season of certain dry years. Such shortages would have occurred in three years during the 25-year period from 1927 through 1951. However, a firm water supply could be obtained from the Delta either from the Feather River or Folsom Projects.

Under the project considered, water would be diverted from the Stockton Deep Water Channel and pumped a distance of about 20,000 feet in a pipe line to a treatment plant near the intersection of the Stockton Deep Water Channel and Buckley Cove. After treatment the water would be pumped easterly a distance of 15,000 feet through a pipe line to a point at the intersection of Brookside and Mission Roads. From this point the water would flow into main branch pipe lines, and then would be further distributed in a number of laterals and stubs to pumping plants of the California Water Service Company presently serving the City of Stockton and an area north of the Calaveras River. The new Delta water supply would be substituted for the supply presently obtained from ground water by the company. This plan is hereinafter referred to as the "Delta-Stockton Diversion Project," and its principal features are delineated on Plate 24, entitled "Delta-Stockton Diversion Project."

The Delta-Stockton Diversion Project was designed to provide a seasonal diversion of 30,000 acre-feet of supplemental water, of which about 17,800 acre-feet would be necessary to meet the present supplemental requirement of the Calaveras Unit, and the remainder would be available for future growth in requirement. An examination of records of the California Water Service Company for 1947 and 1948 indicated that the maximum monthly demand for water in the City of Stockton constitutes about 15 per cent of the total seasonal demand. The maximum daily delivery demand was assumed to be 20 per cent greater than the average daily demand in the maximum month. In terms of continuous flow rates, the maximum monthly and maximum daily diversions would amount to about 75 and 87 second-feet, respectively. These derived values are equivalent to about 50 and 60 million gallons daily. The project was designed with treatment plant capacity of 50 million gallons daily and storage capacity of 17 million gallons, which capacities would meet the estimated maximum daily rate of demand. Existing storage tanks on the distribution system in the City of Stockton, having a total capacity of about 3 million gallons, would assist in meeting daily variation in demand.

Lands in the Western Mokelumne Unit north of the Calaveras River, and lands in the Calaveras Unit south of that river that would be served by the new water supply comprise about 4,000 acres and 17,000 acres, respectively. Use of the new water supply would eliminate progressive lowering of ground water levels in the Calaveras Unit, and would provide a new ground water supply of about 12,200 acre-feet per season in the Western Mokelumne and Calaveras Units. These estimates were based on examination of recent delivery records of the California Water Service Company, and on records for similar urban areas, which indicate that a seasonal delivery of water in an amount of about 1.75 acre-feet per gross acre would be required.

Under the plan considered, the diversion of water from the Sacramento-San Joaquin Delta would be made in about the center of Section 27, Township 2 North, Range 5 East, M. D. B. & M. Minimum water surface elevation at the point of diversion would be about minus 1.0 foot. The diverted water would be pumped by a battery of electrically-driven low-head pumps, comprising 5 pumps of 21.6 million gallons daily capacity each, or a total installed capacity of 108 million gallons daily. Each pump would be driven by a 300 horsepower motor. The pumps would be of the vertical, axial-flow type, and would operate under a maximum head of 53 feet. The pumps and motors would be housed in a reinforced-concrete structure set on piles. The bottom of the housing structure would be at an elevation of about minus 14 feet, and the top at an elevation of about 29 feet. Water from the pumping plant would be conveyed generally in a southeasterly direction a distance of about 20,000 feet through a 54-inch diameter mortar-lined steel pipe and a siphon under Buckley Cove. The steel pipe siphon would be 54 inches in diameter, 800 feet in length, and encased in concrete for a distance of about 600 feet. The average soil cover over the siphon would be about 5 feet.

Water from the siphon would be conveyed to four reinforced-concrete mixing tanks, each 30 feet in width by 50 feet in length and 10 feet in depth. The tanks would be provided with round-the-end baffles spaced two feet apart, and each mixing tank would serve three reinforced-concrete flocculation tanks. The flocculation tanks would be 25 feet in width by 25 feet in length and 15 feet in depth, and the elevation of the bottom of the tanks would be about 21 feet. From the flocculation tanks the water would be conveyed to four mechanically cleaned reinforced-concrete sedimentation tanks, each 80 feet in width by 237 feet in length and 15 feet in depth.

In the operation of the sedimentation tanks a detention period of four hours was assumed for the water in transit. Water from the sedimentation tanks would be conveyed to 24 rapid sand filters, each 24 feet in width by 30 feet in length and 15 feet in depth. The filters would be constructed with a drain near the bottom of the reinforced-concrete structure, overlain with a layer of 2 feet of gravel and 3 feet of sand. The water would filter through the sand and gravel. A portion of the filtered water would be pumped to a filter back-wash water tank. This tank would have a capacity of 150,000 gallons, and its bottom elevation would be at least 40 feet above the filters. After chlorination, the remaining portion of the filtered water would flow by gravity to a reinforced-concrete storage reservoir having a capacity of 17 million gallons. The reservoir would be 340 feet in width by 340 feet in length, and 20 feet in depth. The elevation of the bottom of the reservoir would be about at sea level.

From the reservoir the treated water would be pumped easterly through a 48-inch diameter reinforced-concrete pipe a distance of about 15,000 feet to the intersection of Brookside and Mission Roads. The pumping plant would consist of a battery of six electrically driven high-head pumps, two with capacity of 12 million gallons daily, two of 10 million gallons daily, and two of 8 million gallons daily, or a total installed capacity of 60 million gallons daily. The pumps would be driven by electric motors, two of 600 horsepower, two of 450 horsepower, and two of 400 horsepower, respectively. The pumps would be of the horizontal centrifugal, mixed-flow type, and would operate under a maximum head of 70 pounds per square inch, equivalent to about 160 feet of head. The pumps and motors would be housed in a reinforced-concrete structure.

From the terminus of the foregoing pipe line, the water would be conveyed to 18 existing pumping and booster plants of the California Water Service Company, and would have a residual pressure of from 10 to 20 pounds per square inch. The water would be conveyed through main branch lines, five of which would be made up of modified prestressed cylindrical reinforced-concrete pipe. These lines would comprise 13,600 feet of 36-inch diameter pipe, 27,000 feet of 30-inch diameter pipe, and 14,200 feet of 24-inch diameter pipe. Two other branch lines would be made of welded steel pipe, comprising 1,100 feet of 22-inch diameter pipe, and 5,400 feet of 20-inch diameter pipe. In addition, the area north of the Calaveras River lying in the Western Mokelumne Unit would be served from a main branch welded steel pipe line, 20 inches in diameter and 15,000 feet in length. The branch line would extend from the intersection of Brookside Road and Pacific Avenue north along Pacific Avenue. From certain of the main branch lines, portions of the water would be conveyed through five lateral and stub pipe lines, constructed of welded steel pipe. These lines would comprise 11,200 feet of 16-inch diameter pipe, 17,800 feet of 14-inch diameter pipe, 12,800 feet of 12-inch diameter pipe, and 17,100 feet of 10-inch diameter pipe. In selecting routes of main branch lines, laterals, and stubs, within the City of Stockton, every effort was made to choose streets having only small existing water mains, to avoid existing business districts, and to avoid heavily traveled streets.

In the design of the project, provision was made for a booster pumping plant which would be located at the intersection of Grant and Lafayette Streets. This plant would consist of four electrically driven pumping units, two of 4 million gallons daily capacity each, and two of 3 million gallons daily capacity each. The larger pumps would be driven by 125-horsepower motors, and the smaller by 100-horsepower motors. The maximum pumping head would be 65 pounds per square inch, or an equivalent head of 150 feet.

Pertinent data with respect to general features of the Delta-Stockton Diversion Project as designed for cost estimating purposes are presented in Table 57.

Capital costs of the Delta-Stockton Diversion Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be about \$12,442,000. Corresponding annual costs were estimated to be about \$906,000. The resultant estimated average unit cost of the 30,000 acre-feet per season of water diverted, treated, and delivered to existing pumping plants serving the distribution system in the City of Stockton, and delivered to a service area north of the Calaveras River, was about \$30.20 per acre-foot, not including costs for firming up the diverted supply from the Delta with water from the Feather River or Folsom Projects. On a 4 per cent interest basis, the estimated unit cost of the new water supply per season was about \$33.50 per acre-foot.

Estimated capital and annual costs of the Delta-Stockton Diversion Project on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
Diversion works and treatment plant	\$9,298,000	\$700,000
Conduit, branches, and laterals	3,106,000	183,000
Booster pumping plant	38,000	23,000
TOTALS	\$12,442,000	\$906,000

TABLE 57

GENERAL FEATURES OF DELTA-STOCKTON DIVERSION PROJECT

Pumping Plants

- Low-head intake plant
  - Pumps—5 vertical, axial-flow type, capacity of 21.6 million gallons daily each
  - Estimated minimum water surface elevation at intake—Minus 1.0 foot
  - Estimated maximum pumping head—53 feet
  - Installed pumping capacity—108 million gallons daily
  - Estimated maximum monthly demand—50 million gallons daily
  - Estimated maximum daily demand—60 million gallons daily
  - Estimated gross seasonal diversion—30,000 acre-feet
  - Motors—5 all-weather type, 300-horsepower each
  - Pump support—Reinforced-concrete slab on concrete piles
- High-head delivery plant
  - Pumps—2 horizontal, centrifugal, mixed-flow type, capacity of 12 million gallons daily each
    - 2 horizontal, centrifugal, mixed-flow type, capacity of 10 million gallons daily each
    - 2 horizontal, centrifugal, mixed-flow type, capacity of 8 million gallons daily each
  - Estimated average water surface elevation at intake—19.0 feet
  - Estimated maximum pumping pressure head—160 feet
  - Installed pumping capacity—60 million gallons daily
  - Motors—2 all-weather type, 600-horsepower
    - 2 all-weather type, 450-horsepower
    - 2 all-weather type, 400-horsepower
  - Pump support—Reinforced-concrete slab on concrete piles
- Booster pumping plant
  - Pumps—2 horizontal, centrifugal, mixed-flow type, capacity of 4 million gallons daily each
    - 2 horizontal, centrifugal, mixed-flow type, capacity of 3 million gallons daily each
  - Estimated maximum pumping pressure head—150 feet
  - Installed pumping capacity—14 million gallons daily
  - Estimated maximum pumping demand—10 million gallons daily
  - Motors—2 all-weather type, 125-horsepower
    - 2 all-weather type, 100-horsepower
  - Pump support—Reinforced-concrete slab on concrete piles

Treatment plant

- Flocculation tanks—Reinforced-concrete structure, 12 tanks, each 25 feet wide, 25 feet long, and 15 feet deep
- Sedimentation tanks—Reinforced-concrete structure, 4 tanks, each 80 feet wide, 237 feet long, and 15 feet deep; 4-hour detention period
- Rapid sand filters—Reinforced-concrete structure, 24 filters, each 24 feet wide, 30 feet long, and 15 feet deep; 2-foot gravel layer, and 3-foot sand layer
- Storage reservoir tank—17 million gallon capacity; reinforced-concrete structure 340 feet wide, 340 feet long, and 20 feet deep

Conveyance system

- Intake conduit—20,200 feet, 54-inch diameter mortar-lined steel pipe
- Main conduit—15,000 feet, 48-inch diameter reinforced-concrete pipe
- Main branches—13,600 feet, 36-inch diameter modified prestressed reinforced-concrete pipe
  - 27,000 feet, 30-inch diameter modified prestressed reinforced-concrete pipe
  - 14,200 feet, 24-inch diameter modified prestressed reinforced-concrete pipe
  - 1,100 feet, 22-inch diameter welded steel pipe, 7 gage
  - 5,400 feet, 20-inch diameter welded steel pipe, 7 gage
  - 15,000 feet, 20-inch diameter welded steel pipe, 7 gage
- Laterals and stubs—11,200 feet, 16-inch diameter welded steel pipe, 7 gage
  - 17,800 feet, 14-inch diameter welded steel pipe, 7 gage
  - 12,800 feet, 12-inch diameter welded steel pipe, 7 gage
  - 17,100 feet, 10-inch diameter welded steel pipe, 7 gage

New Hogan Project

Construction of an enlarged dam and reservoir on the Calaveras River at the Hogan site would provide new irrigation yield to meet the present supplemental water requirements in the Calaveras Unit, and for growth in water utilization for a number of years into the future. It would also provide new irrigation yield to meet a portion of the present supplemental water requirement in the Littlejohns Unit. Use of the new water supply would prevent or reduce progressive lowering of ground water levels in the Calaveras Unit, and would reduce such lowering in the Littlejohns Unit. In addition, a large measure of flood protection would be provided to downstream areas adjacent to the Calaveras River. The enlarged dam would be an earthfill structure at the site of existing Hogan Dam, located on the Calaveras River in Section 31, Township 4 North, Range 11 East, M. D. B. & M., about three miles south of the town of Valley Springs and about eight miles east of the San Joaquin-Calaveras county line. Facilities for conveyance of the conserved water to service areas in the Calaveras and Littlejohns Units would also be included. The plan is hereinafter referred to as the "New Hogan Project," and its principal features are delineated on Plate 25, entitled "New Hogan Project."

Construction of the New Hogan Dam and Reservoir has been authorized by the Federal Government and by the State of California, but funds for construction of the project by the Corps of Engineers, United States Army, have not been appropriated by the Congress. The 315,000 acre-foot storage capacity considered for the New Hogan Reservoir for purposes of this bulletin is the same as that proposed by the Corps of Engineers, and, in accordance with recommendations of the Corps of Engineers, a maximum flood control storage reservation of 125,000 acre-feet was likewise adopted. The New Hogan Dam would almost completely envelop the existing structure, the outlets of which would be permanently plugged with concrete. Four auxiliary saddle dams would be required to complete the closure at low saddles on the reservoir rim. The spillway would be an open channel in cut, located south of the left abutment of the most southerly auxiliary dam. Flood waters of the Calaveras River conserved by the reservoir would be released to the stream, for subsequent diversion and conveyance to downstream service areas, and for replenishment of the ground water supply.

It was estimated that mean seasonal runoff of the Calaveras River, from the 363 square miles of drainage area above the dam site, is about 187,000 acre-feet. Based upon yield studies during the critical dry period from 1920-21 through 1934-35, together with topography of the dam site and cost analyses hereinafter discussed, a reservoir of 315,000 acre-foot storage capacity, with estimated new seasonal irrigation yield of 48,000 acre-feet, was chosen for purposes of cost estimates to be presented in this bulletin. This yield would be in addition to the present yield that could be developed from the existing Hogan Reservoir by making stream channel releases in accordance with established operational criteria, and under more efficient operation. The present possible yield from the existing reservoir under such operation would be about 40,000 acre-feet per season. This operation would involve the release of 100 acre-feet of water per day, when available, into the Calaveras River and Mormon Slough channels for ground water replenishment, plus additional releases of water for downstream diversion for irrigation of some 6,200 acres of land adjacent to the foregoing channels. The yield study for this size of reservoir is included in Appendix K.

The new seasonal yield of 48,000 acre-feet of water that would be developed by the New Hogan Project was allocated as follows, for purpose of this study: Calaveras Unit, 30,000 acre-feet, and Littlejohns Unit, 18,000 acre-feet. It was estimated that losses of water in conveyance and distribution of the 30,000 acre-feet per season of new irrigation yield assigned to the Calaveras Unit would be about 25 per cent, leaving some 22,500 acre-feet of water for application to irrigated lands. Similar losses in conveyance and distribution of the 18,000 acre-feet per season of new irrigation yield assigned to the Littlejohns Unit were estimated to be about 20 per cent, leaving some 14,400 acre-feet for application to irrigated lands.

Although the foregoing losses in the proposed unlined conveyance and distribution systems would reduce the acreage that could be irrigated from the surface supply, such losses would augment the ground water supplies by percolation, thus preventing or reducing progressive lowering of ground water levels. This would follow, since the Calaveras and Littlejohns Units overlie a free ground water basin, wherein such percolation can occur.

Based on the results of studies discussed in Chapter III, it was estimated that the average seasonal application of the new water supply to lands in the Calaveras Unit would be to lands devoted principally to field crops and irrigated pasture, and would be about 4.0 acre-feet per acre. Similarly, it was estimated that the average seasonal application of the new water supply to lands in the Littlejohns Unit would be to lands devoted principally to rice and ladino clover, and would be about 6.0 acre-feet per acre. On this basis, it was estimated that the new water supply would be applied to about 5,600 acres of lands in the Calaveras Unit and about 2,400 acres of lands in the Littlejohns Unit. It was further estimated, from studies discussed in Chapter III, that the seasonal consumptive use of irrigation water applied to the foregoing crops would be 2.2 and 3.8 acre-feet per acre for the Calaveras and Littlejohns Units, respectively. Based on these values, percolation of the unconsumed water applied to irrigated lands, plus percolation losses from the unlined conveyance and distribution system, would augment ground water supplies in the Calaveras and Littlejohns Units by 17,700 acre-feet and 8,900 acre-feet per season, respectively.

The design capacities of the conveyance canals to the Calaveras and Littlejohns Units were based on the maximum monthly irrigation demand which occurs during the month of July and, as shown in Table 39, amounts to 22 per cent of the total seasonal irrigation demand. These maximum monthly demands for the foregoing diversions were determined to be about 105 second-feet and 65 second-feet, on a continuous flow basis, for the Calaveras and Littlejohns Units, respectively. Conveyance canals serving the respective units were designed for capacities of 125 second-feet and 85 second-feet, to provide for short-term peaking in excess of the average maximum monthly demand.

A topographic survey of the New Hogan dam site up to an elevation of 730 feet was made by the Corps of Engineers in 1947, and a map was drawn to a scale of 1 inch equals 200 feet and with a contour interval of 5 feet. Storage capacities of the New Hogan Reservoir at various stages of water surface elevation, based on the area-capacity curve for New Hogan Reservoir prepared by the Corps of Engineers and dated October 7, 1947, are given in Table 58.

TABLE 58

AREAS AND CAPACITIES OF NEW HOGAN RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	529	0	0
11	540	40	300
31	560	220	2,000
51	580	610	10,800
71	600	1,050	27,200
91	620	1,530	52,700
111	640	2,100	89,000
131	660	2,670	137,000
151	680	3,260	196,800
171	700	3,910	269,700
182	711	4,280	315,000
191	720	4,580	353,000

Based upon preliminary geological reconnaissance, the New Hogan dam site is considered to be suitable for an earthfill dam of any height up to at least 200 feet. The principal geologic features at the dam site are the strong jointing, the shearing associated with the schistosity, and the deep weathering of the rock. However, there is no doubt but that a suitable foundation can be developed at this site for the proposed structure. Materials for the construction of an earthfill dam are available within feasible haul distances. Impervious fill could be obtained in thin layers from the surface of sloping meadowlands within the reservoir area. Additional impervious fill, if needed, could be borrowed from land near the community of Valley Springs to the north. Dredger tailings from within the reservoir area, and from the river channel downstream as far as the mouth of Cosgrove Creek, could be used in the pervious sections of the dam, and as riprap on the main dam and saddle dams.

The main dam would be underlain entirely by meta-volcanic rocks, excepting for a small area of igneous rock occurring about half way up the right abutment near the downstream toe. Many of the metavolcanics are classifiable as talc schists, and show varying degrees of weathering. The schistosity developed in the metamorphics strikes approximately at right angles to the stream channel, and generally dips steeply upstream. Numerous strong joint systems also occur throughout the rock mass. These joints, coupled with the schistosity, rather completely break up the foundation material. Several small sheared or brecciated zones, which are generally associated with the schistosity, occur locally as well. Some of these zones were seeping water at the time of the geologic field investigation. Weathering of the entire mass to a considerable depth has occurred, due primarily to percolation of water along the joint sets and shear zones. Average required stripping normal to the surface is estimated to be 55 feet on the right abutment, 30 feet in the channel section, and 45 feet on the left abutment, under the impervious section only of the dam.

The spillway might best be cut through ridges south of the dam site, with discharge into a tributary stream entering the river channel well downstream from the toe of the dam. The entire spillway channel would have to be lined, and, for stability, side slopes should not be steeper than 1 : 1. Depth of cut to sound rock may be relatively great across these ridges.

The reservoir would inundate approximately 5,000 acres, and would require the acquisition of approximately 2,175 acres of new land, of which 1,625 acres would require clearing of a thin growth of trees and brush. An arm of the reservoir is crossed by State Highway 12 and by a branch of the Southern Pacific Railway, but relocation problems would not be difficult, even though the existing railroad bridge and a nearby rock fill would be partially inundated during a major flood. A 12-inch diameter natural gas pipe line which traverses the reservoir area would require relocation for a distance of 6.2 miles.

As a result of yield studies, geologic reconnaissance, and preliminary economic analysis, an earthfill dam 182 feet in height from stream bed to spillway lip, and with a crest elevation of 730 feet, was selected to illustrate estimates of cost of the New Hogan Project. The dam would have a crest length of 1,850 feet, a crest width of 30 feet, and 3 : 1 upstream and 2.5 : 1 downstream slopes. The central impervious core would have a crest width of 10 feet, and slopes of 0.75 : 1. Pervious fill would consist of dredger tailings and materials salvaged from excavation for the spillway. Graded coarse dredger tailings would be utilized to blanket the upstream face. A concrete cutoff would be required under the impervious core, and series of holes about 30 feet deep and 5 feet on centers along the cutoff axis would be thoroughly grouted to insure against excessive underseepage. The total volume of fill would be an estimated 3,806,000 cubic yards.

Four small auxiliary saddle dams would be required for a reservoir of the chosen capacity. Two of the auxiliary dams would be located across saddles just south of the left abutment of the main dam, and would be extensions of the main dam. Their crest lengths would total about 1,750 feet, and their maximum height would be about 50 feet. The crest width of each would be 30 feet, with 3 : 1 upstream and 2.5 : 1 downstream slopes. The other two auxiliary dams would be located across saddles about 6,000 feet and 8,000 feet north of the right abutment of the main dam. Their crest lengths would total about 1,870 feet, and their maximum height would be about 14 feet. The crest width of each would be 20 feet, and the side slopes would be 2.5 : 1. The upstream faces of the auxiliary dams would be blanketed with 3 feet of riprap. The total volume of fill in the auxiliary dams would be an estimated 466,000 cubic yards, all of which would be impervious fill except for the riprap.

The spillway would be of the chute type, located in an open channel in cut south of the left abutment of the most southerly auxiliary dam. The control structure would consist of an ogee weir, 400 feet in length, and would be followed by a discharge channel which would be concrete-lined for a distance of 1,100 feet. The elevation of the spillway lip would be 711 feet. The maximum depth of water above the spillway lip would be 15 feet, and an additional 4 feet of freeboard would be provided. The spillway would have a capacity of 80,000 second-feet, required for an assumed maximum discharge of 220 second-feet per square mile of drainage area. The spillway would discharge into a ravine which drains into the Calaveras River about 0.75 mile downstream from the dam.

The outlet works would utilize a diversion tunnel constructed through the south abutment of the main dam. The approach channel to the diversion tunnel would be a 700-foot long open cut, with 25-foot bottom width and 1 :1 side slopes. The invert of the tunnel would be level through the dam at an elevation of 560 feet. The tunnel would be 700 feet in length, circular in section, 16 feet in diameter, and unlined for the first 400 feet except for the intake headwall. The remaining 300 feet of tunnel would be a 24.5-foot diameter, lined, horseshoe section. A concrete bulkhead at the end of the 400-foot round tunnel section would distribute the discharge to two 10-foot diameter and one 7-foot diameter steel pipes supported on concrete cradles with suitable ring stiffening girders. These pipes would be located in the horseshoe tunnel, which would also provide access for servicing and operation of emergency gates to be located at the bulkhead. The gates would be of the butterfly type, mechanically operated, two of 10-foot diameter and one of 7-foot diameter. Releases from the reservoir would be regulated by three Howell-Bunger valves of the same nominal sizes as the steel pipes, and located at the outlet portal. They would discharge into a reinforced-concrete stilling basin about 100 feet in length, 50 feet in width and 17 feet in depth, and depressed about 15 feet below the tunnel invert. The stilling basin would be followed by about 1,250 feet of unlined channel excavated in open cut. The channel would have a bottom width of 50 feet and side slopes of 1:1, and would enter the river about 500 feet downstream from the toe of the dam. The capacity of the outlet works would be about 10,000 second-feet.

Lands in the Calaveras Unit would be served from New Hogan Reservoir by diverting the released water from Mormon Slough into the Calaveras River channel at Bellota, conveying this water down the Calaveras River channel to a point north of Linden, and rediverting the water into a canal to the service area situated south of the Calaveras River channel. This diversion is hereinafter referred to as the "Bellota-Linden Diversion." Under the plan the existing diversion weir on Mormon Slough at Bellota would be utilized to divert water into the Calaveras River channel, and the existing control works at the head of the Calaveras River channel would also be utilized to regulate releases into that channel. Water would flow down the Calaveras River channel a distance of about four miles to an existing diversion weir constructed by the Linden Irrigation District. This weir is located in the southwest quarter of Section 2, Township 2 North, Range 8 East, M. D. B. & M., at the Clements Road, about 2.5 miles north of Linden. Diversion at this point would be accomplished by construction of a reinforced-concrete headwall on the south bank of the Calaveras River channel immediately upstream from the existing weir. The headwall would be recessed from the channel and would be 12 feet in height, 10 feet in width, and would be provided with a 10-foot wing wall at each end, extending toward the channel at an angle of 30 degrees from the headwall. The headwall would be provided with two 42-inch diameter slide gates, each of which would discharge into a 42-inch diameter corrugated steel pipe. The capacity of the diversion works would be 125 second-feet. The two corrugated pipes would convey the water a distance of about 140 feet south and under Waterloo Road, to an unlined canal about 20 feet south of Waterloo Road.

The unlined canal, with capacity of 125 second-feet, would be of trapezoidal section, with 2:1 side slopes, bottom width of 8 feet, depth of 5 feet, and freeboard of 1 foot. The elevation of the bottom of the canal at its head would be 96 feet. Its slope would be approximately 2 feet per mile, and the velocity would be about 1.8 feet per second. The canal would follow a southerly route for a distance of about 1 mile, then would turn west along Baker Road, and follow that road on its south side for approximately 4 miles to a terminus at Jack Tone Road, where the elevation of the canal bottom would be about 63 feet. Because of excessive slope of the ground along the proposed route, a series of reinforced-concrete drop structures in the canal would be necessary. These would include three 5-foot drops and one 4-foot drop. The canal would pass under six roads along its route by means of inverted siphons, consisting of two 48-inch diameter corrugated steel pipes at each underpass.

For purposes of estimates of cost, it was proposed that lands in the Littlejohns Unit would be served new water from the New Hogan Project by a gravity diversion of reservoir releases at the head of Mormon Slough at Bellota, and by conveyance of this water in an unlined canal in a southerly direction for a distance of about 13 miles, where it would discharge into Duck Creek about one mile northeast of Farmington. This diversion is hereinafter referred to as the "Bellota-Farmington Diversion." The point of diversion from Mormon Slough would be at the site of the existing diversion weir owned by the Stockton and East San Joaquin Water Conservation District, located in the southwest quarter of Section 5, Township 2 North, Range 9 East, M. D. B. & M. The existing weir would be replaced by a larger structure. The new weir would consist of a concrete gravity overpour section, 9 feet in height above stream bed, with a crest elevation of 120 feet, and 100 feet in length, and would pass a flood discharge of about 22,000 second-feet with a surcharge of 10 feet. Flashboards would be installed on the existing gate structure at the head of the Calaveras River channel to prevent uncontrolled spill of the water into that channel. The headworks of the Bellota-Farmington Diversion would consist of a reinforced-concrete box on the left bank of Mormon Slough, about 20 feet wide, 30 feet long, and 10 feet in height, provided with a 5-foot by 5-foot slide gate in the headwall, through which releases to the canal would be made. Two 30-inch by 30-inch sluice gates would be provided for sand flushing.

The Bellota-Farmington Diversion, with a capacity of 85 second-feet, would be unlined, and would be of trapezoidal section, with 2:1 side slopes, bottom width of 6 feet, depth of 4.4 feet, and freeboard of 1 foot. The elevation of the bottom of the canal at its head would be 114 feet. Its slope would be approximately 1.2 feet per mile, and the velocity would be about 2.0 feet per second. The canal would follow the Escalon-Bellota Road in a southerly direction for about one mile, then would turn westerly a distance of about a mile, and southerly for the remaining 11 miles to its terminus, generally following the natural contour of the ground. The elevation of the canal bottom at its terminus would be about 95 feet.

Pertinent data with respect to general features of the New Hogan Project, as designed for cost estimating purposes, are presented in Table 59.

The capital cost of the New Hogan Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be about $10,364,000. The corresponding annual costs were estimated to be about $447,000. The resultant estimated unit cost of the 48,000 acre-feet per season of new irrigation yield conserved by the project was about $9.30 per acre-foot. On a 4 per cent interest basis, the unit cost of the new irrigation yield per season was about $11.00 per acre-foot. These estimates are subject to reduction in the amount that the Federal Government would contribute toward the project in the interest of flood control. Based on information supplied by the Corps of Engineers, the average annual direct flood control benefits creditable to the New Hogan Project would be about $320,000. If a contribution equivalent to $320,000 annually were made by the Federal Government in the interest of flood control, the estimated unit cost of the new irrigation yield per season would be about $2.65 per acre-foot on a 3 per cent interest basis, and about $4.30 per acre-foot on a 4 per cent interest basis.

Estimated capital and annual costs of the New Hogan Project on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
New Hogan Dam and Reservoir	$9,768,000	$418,000
Bellota-Linden Diversion	310,000	15,000
Bellota-Farmington Diversion	286,000	14,000
TOTALS	$10,364,000	$447,000

Delta-Littlejohns Diversion Project

The present requirement for supplemental water in the Littlejohns Unit could be provided by a pumped diversion of water from the Sacramento-San Joaquin Delta. A satisfactory site for such a diversion exists on French Camp Slough, about 0.2 mile north of French Camp. Water available in the Sacramento-San Joaquin Delta, over and above requirements of the Central Valley Project and other established rights and commitments, would be insufficient to meet requirements in the Littlejohns Unit in some months during the irrigation season of certain dry years. Such shortages would have occurred in 11 years during the 25-year period from 1927 through 1951. However, a firm water supply could be obtained in the Delta either from the Feather River or Folsom Projects.

TABLE 59

GENERAL FEATURES OF NEW HOGAN PROJECT

Main Earthfill Dam
- Crest elevation—730 feet
- Crest length—1,850 feet
- Crest width—30 feet
- Height, spillway lip above stream bed—182 feet
- Side slopes—3:1 upstream
  2.5:1 downstream
- Freeboard, above spillway lip—19 feet
- Elevation of stream bed—529 feet
- Volume of fill—3,806,000 cubic yards

Auxiliary Earthfill Dams
- South saddle dams (2)
  - Crest lengths, total—1,750 feet
  - Crest widths—30 feet
  - Side slopes—3:1 upstream
    2.5:1 downstream
  - Maximum height—50 feet
- North saddle dams (2)
  - Crest lengths, total—1,870 feet
  - Crest widths—20 feet
  - Side slopes—2.5:1
  - Maximum height—14 feet

Volume of fill, all saddle dams—466,000 cubic yards

Reservoir
- Surface area at spillway lip—4,500 acres
- Capacity at spillway lip—315,000 acre-feet
- Flood control reservation—125,000 acre-feet
- Drainage area—363 square miles
- Estimated mean seasonal runoff—187,500 acre-feet
- Estimated new seasonal irrigation yield—48,000 acre-feet
- Type of spillway—Concrete-lined chute with ogee weir control section
- Spillway capacity—80,000 second-feet
- Type of outlet—Two 10-foot diameter and one 7-foot diameter steel pipes in tunnel
- Outlet capacity—10,000 second-feet with water surface at elevation of 679 feet

Bellota-Linden Diversion
- Diversion Works—Existing diversion weir on Mormon Slough; reinforced-concrete weir with flashboard; crest length 110 feet, crest elevation 114 feet. Existing control works at head of Calaveras River channel, to regulate diversion into that channel; gated overpour reinforced-concrete control structure; four 4-foot by 4-foot hand-operated gate valves; elevation, bottom of gates 107.8 feet. Existing diversion weir on Calaveras River channel, owned by Linden Irrigation District, approximately 5 feet high above stream bed, crest elevation of about 102 feet. Reinforced-concrete headworks provided with two 42-inch slide gates.

Conveyance conduit

Type	Trapezoidal, unlined
Length, in miles	4.9
Side slopes	2:1
Bottom width, in feet	8
Depth, in feet	5
Freeboard, in feet	1
Slope, in feet per mile	1.8
Velocity, in feet per second	2.0
Capacity, in second-feet	125

Bellota-Farmington Diversion
- Diversion weir—Concrete gravity weir, with overpour section, 100 feet in length, 9 feet high above stream bed, crest elevation about 120 feet. Reinforced-concrete headworks provided with a 5-foot by 5-foot slide gate and two 30-inch by 30-inch sluice gates.

Conveyance conduit

Type	Trapezoidal, unlined
Length, in miles	12.7
Side slopes	2:1
Bottom width, in feet	6.0
Depth, in feet	4.4
Freeboard, in feet	1.0
Slope, in feet per mile	1.2
Velocity, in feet per second	2.0
Capacity, in second-feet	85

Under the plan considered, water pumped from the Delta would be conveyed upstream in the channel of Littlejohns Creek by means of a series of pump lifts to two points of delivery above Farmington. Water would be diverted enroute to service areas in the Littlejohns Unit lying north and south of Littlejohns Creek. This plan is hereinafter referred to as the "Delta-Littlejohns Diversion Project," and its principal features are delineated on Plate 26, entitled "Delta-Littlejohns Diversion Project."

The Delta-Littlejohns Diversion Project was designed to provide a seasonal diversion of 60,000 acre-feet of supplemental water, of which 20,000 acre-feet would be served north of Littlejohns Creek and the remainder south of the creek. About 50,500 acre-feet of the new water per season would be necessary to meet the present supplemental requirement of the Littlejohns Unit, and the remainder would be available for additional development of irrigable lands.

It was estimated that losses in conveyance and distribution of the new water supply would be about 20 per cent of the gross diversion, leaving about 48,000 acre-feet per season for application to lands. Based on an indicated seasonal irrigation application of 6.0 acre-feet per acre to lands in the Littlejohns Unit, the new water supply could serve some 8,000 acres. As stated in the foregoing section on the New Hogan Project, the seasonal consumptive use of applied water in the Littlejohns Unit was estimated to be 3.8 acre-feet per acre. On this basis, percolation from the unconsumed portion of applied irrigation water, plus canal percolation losses, would augment ground water supplies in the Littlejohns Unit by some 29,600 acre-feet per season.

The capacity of the diversion works and conveyance conduit was designed to be 250 second-feet, which capacity would provide for the maximum monthly demand rate of 213 second-feet, plus additional capacity for shorter-term peaking in excess of the maximum monthly rate. The maximum elevation of the area served is about 125 feet.

The Corps of Engineers, United States Army, has plans for aligning and enlarging three channels of Littlejohns Creek to increase their flood flow capacity to 1,050 second-feet, 750 second-feet, and 250 second-feet, respectively. These plans contemplate similar work in the portion of French Camp Slough between the mouth of Littlejohns Creek and the Western Pacific Railroad trestle. The resulting channel of French Camp Slough below the mouth of Littlejohns Creek will have a bottom width of 40 feet, and 2:1 side slopes. The channel of Littlejohns Creek having a flood flow capacity of 1,050 second-feet will have a bottom width of 25 feet and 2:1 side slopes. Estimates of costs for the Littlejohns Project reported herein contemplate the use of these improved channels for the project, thus substantially reducing channel excavation and rights of way costs.

Under the plan considered, the diversion of surplus water from the Sacramento-San Joaquin Delta would be made from French Camp Slough by a pumping plant located in the southwest quarter of Section 36, Township 1 North, Range 6 East, M. D. B. & M. The channel of French Camp Slough would be dredged downstream from the pumping plant for a distance of approximately 2,500 feet. The elevation of the bottom of the dredged channel at the pumping plant would be minus 4.0 feet. The elevation of the delta water surface at point of diversion is subject to tidal fluctuation, and would vary from a minimum elevation of about minus 1 foot to a maximum elevation of about 5.0 feet, and would average about 2.0 feet.

At the point of diversion the water would be pumped into a pipe placed under the Western Pacific Railroad trestle and French Camp Road, and extending in a southeasterly direction for a distance of about 500 feet, where the water would be discharged behind a radial gate check dam on French Camp Slough at an elevation of about 20 feet. The required pumping plant would effect the first of 10 pumping lifts needed to deliver the diverted water to the upper end of the project at an elevation of about 125 feet, and is designated Pumping Plant No. 1.

Features of a typical pumping plant considered for the Delta-Littlejohns Project are shown on Plate 26. In order to permit flexibility in operation, Pumping Plant No. 1 would consist of a battery of five electrically driven pumps, each of 36-inch diameter and with individual pumping capacities of about 55 second-feet. The pumps would be of the vertical, axial-flow, propeller type, each driven by a 250-horsepower motor, and would operate under a head of about 20 feet. The pumps and motors would be housed in a corrugated metal structure, set on a reinforced-concrete slab which would be mounted on concrete piles. The pumps would lift water from a sump located below the pumping plant. The bottom elevation of the sump would be about minus 6 feet.

The reinforced-concrete pipe into which the pumps would discharge the diverted water would be 5 feet in diameter and would have a capacity of 250 second-feet. The diverted water would be discharged into French Camp Slough just east of the Western Pacific Railroad, behind a check dam which would maintain the water surface elevation behind the dam at 20 feet. The dam would be equipped with two 10-foot radial gates, 30 feet in length, with motor-operated hoists. The gates when closed would seat on the crest of a gravity concrete ogee weir, about 60 feet in length. The crest of the weir would be at an elevation of 10 feet. Auxiliary check dams, provided with removable flashboards, would be necessary on Lone Tree Creek and the north branch of Littlejohns Creek, in order to retain the diverted water in the channel of Littlejohns Creek for its further conveyance eastward to areas of use.

The remaining nine pumping plants that would be required to lift the diverted water to areas of use were designated Pumping Plants Nos. 2 to 10, consecutively, and their locations would be about 19,000 feet, 28,000 feet, 38,000 feet, 48,000 feet, 60,000 feet, 73,000 feet, 89,000 feet, 100,000 feet, and 108,000 feet, respectively, upstream on Littlejohns Creek from Pumping Plant No. 1. At Pumping Plant No. 10 a portion of the new water supply would be pumped in a northeasterly direction a distance of about 3,700 feet to an elevation of about 125 feet. The remainder of the new supply would be pumped southwesterly from Plant No. 10 a distance of about 1,000 feet, also to an elevation of about 125 feet.

In order to permit flexibility in operation of the project, design of Pumping Plants Nos. 2 through 9 was based on installation of five electrically driven, vertical, axial-flow, propeller type pumping units at each plant. Each of the units would comprise a 42-inch diameter pump with capacity of 55 second-feet, driven by a 100-horsepower motor. The pumps would be operated at a maximum pumping head of about 12 feet at each plant. The pumping units would be of the all-weather type, mounted on a reinforced-concrete slab. The units would pump from sumps into the upstream pools, formed by a check dam equipped with a 10-foot radial gate, 22 feet in width, at each pumping lift. The gates would have motor-operated hoists, and would seat on the crest of gravity concrete ogee weirs, with crest lengths of 22 feet. The top of the weir crest would be at the elevation of the natural stream bed at each pumping plant. The radial gates would be so operated that when winter runoff begins, the gates would be in a raised position and the flood flows could pass down the stream channel without impairment. Maximum water surface elevation immediately upstream from Pumping Plants Nos. 1, 2, 3, 4, 5, 6, 7, 8, and 9 would be about 20 feet, 30 feet, 40 feet, 50 feet, 60 feet, 70 feet, 80 feet, 90 feet, and 100 feet, respectively.

The design of Pumping Plant No. 10 contemplated installation of four electrically driven, vertical, axial-flow, propeller type pumping units. The two units pumping water to the northeast would each comprise a 30-inch diameter pump with a capacity of about 45 second-feet, driven by a 400-horsepower motor. The pumps would be operated at a maximum pumping head of about 35 feet. The two units pumping water to the southwest would each comprise a 48-inch diameter pump with a capacity of about 90 second-feet, driven by a 250-horsepower motor. These latter two pumps would be operated at a maximum pumping head of about 28 feet. The pumping units would be of the all-weather type, mounted on reinforced-concrete slabs. The units would pump from a sump excavated to an elevation of about 94 feet between Pumping Plants Nos. 9 and 10.

The conveyance channel between the respective pumping plants, from French Camp Slough to Pumping Plant No. 10, would comprise the existing channel of Littlejohns Creek up to a point approximately midway between the plants. From these approximate mid points, the existing channel would be excavated to the next pumping plant upstream. The excavated channel sections would be trapezoidal in shape, and would vary from a 25-foot bottom width at the beginning of cuts to a 5-foot bottom width at the entrance to the respective pumping plants. The excavated sections would have 2:1 side slopes. The water depth of the excavated sections would be 6.0 feet with 1.0 foot of freeboard.

Conveyance of some 20,000 acre-feet per season of the new water supply to the northeast of Pumping Plant No. 10 would be made through two 48-inch diameter reinforced-concrete pipes, with a total capacity of 90 second-feet. The remainder of the new supply, about 40,000 acre-feet per season, would be conveyed southwesterly through two 66-inch diameter reinforced-concrete pipes with a total capacity of 180 second-feet.

Pertinent data with respect to general features of the Delta-Littlejohns Project, as designed for cost estimating purposes, are presented in Table 60.

The capital cost of the Delta-Littlejohns Diversion Project, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be about $1,614,000. Corresponding annual costs were estimated to be about $282,000. The resultant estimated average unit cost of the 60,000 acre-feet of new water supply per season was about $4.70 per acre-foot, not including costs for firming up the diverted supply from the Delta with water from the Feather River or Folsom Projects. On a 4 per cent interest basis, the estimated unit cost of the new water supply per season was about $4.90 per acre-foot. Detailed cost estimates on a 3 per cent interest basis are presented in Appendix L.

New Melones Project

The present and a large portion of the ultimate supplemental water requirement in the San Joaquin Area could be provided by construction of a dam and reservoir on the Stanislaus River at the New Melones site, and conveyance of the conserved waters to the San Joaquin Area by means of a tunnel, canals, and siphons. The New Melones dam site is located about 0.5 mile downstream from the existing Melones Dam, in Sections 10 and 11, Township 1 North, Range 13 East, M. D. B. & M., about 12 miles upstream from Knights Ferry. Water conserved in the reservoir would be released through an enlarged Melones Power Plant, and would be diverted from the Stanis-

New Melones Dam Site on Stanislaus River

TABLE 60

GENERAL FEATURES OF DELTA-LITTLEJOHNS PROJECT

Pumping Plants
Plant No. 1
Pumps—5 vertical, axial-flow, propellor type, 55 second-foot capacity each
Estimated minimum water surface elevation at plant—Minus 1 foot
Discharge elevation—20 feet
Estimated maximum pumping head—29 feet
Installed pumping capacity—275 second-feet
Estimated maximum monthly demand—213 second-feet
Estimated gross seasonal diversion—60,000 acre-feet
Motors—Vertical shielded squirrel cage, 250-horsepower each
Pump support—Reinforced-concrete slab on concrete piles
Pumping sump—Reinforced-concrete, 15 feet by 30 feet, 15 feet depth, equipped with trash racks

Check Dam
Weir—Reinforced-concrete ogee weir, 60-foot crest length
Gates—Two 10-foot by 30-foot radial gates with motor-operated hoists

Pumping Plants Nos. 2, 3, 4, 5, 6, 7, 8, and 9
Pumps—5 vertical, axial-flow, propellor type, 55 second-foot capacity each
Estimated maximum pumping head—12 feet
Installed pumping capacity—275 second-feet
Estimated maximum monthly demand—213 second-feet
Estimated gross seasonal diversion—60,000 acre-feet
Motors—5 all-weather type, 100-horsepower each
Pump support—Reinforced-concrete slab

Pumping Plants Nos. 2, 3, 4, 5, 6, 7, 8, and 9—Continued
Pumping sump—Right bank, reinforced-concrete, 13 feet by 13 feet, 10 feet in depth, equipped with trash racks
Left bank, reinforced-concrete, 13 feet by 18 feet, 10 feet in depth, equipped with trash racks
Weir—Reinforced-concrete ogee weir, 22-foot crest length
Gate—One 10-foot by 22-foot radial gate with motor-operated hoist

Pumping Plant No. 10
Pumps (northeast)—2 vertical, axial-flow, propellor type, 45 second-foot capacity each
Pumps (southwest)—2 vertical, axial-flow, propellor type, 90 second-foot capacity each
Estimated maximum pumping head (northeast)—35 feet
Estimated maximum pumping head (southwest)—28 feet
Installed pumping capacity (northeast)—90 second-feet
Installed pumping capacity (southwest)—180 second-feet
Estimated maximum monthly demand (northeast)—71 second-feet
Estimated maximum monthly demand (southwest)—142 second-feet
Estimated gross seasonal diversion (northeast)—20,000 acre-feet
Estimated gross seasonal diversion (southwest)—40,000 acre-feet
Motors (northeast)—2 all-weather type, 400-horsepower each
Motors (southwest)—2 all-weather type, 250-horsepower each
Pump support—Reinforced-concrete slabs
Pumping sumps—2 reinforced-concrete, 16 feet by 11 feet, 7 feet in depth, equipped with trash racks

Conveyance System

Reach	Length, in miles	Side slopes	Bottom width, in feet	Depth, in feet	Freeboard, in feet	Velocity, in feet per second	Capacity, in second-feet
French Camp Slough to Littlejohns Creek	2.2	2:1	40	variable 5 to 10	variable 1 to 6	variable 0.4 to 1	250
Littlejohns Creek to Plant No. 2	1.3	2:1	variable 25 to 5	5.0	variable 1 to 10	variable 1.4 to 3.3	250
Plant No. 2 to Plant No. 3	1.8	2:1	variable 25 to 5	variable 10 to 5	variable 1 to 10	variable 1.4 to 3.3	250
Plant No. 3 to Plant No. 4	1.8	2:1	variable 25 to 5	variable 10 to 5	variable 1 to 10	variable 1.4 to 3.3	250
Plant No. 4 to Plant No. 5	2.0	2:1	variable 25 to 5	variable 10 to 5	variable 1 to 10	variable 1.4 to 3.3	250
Plant No. 5 to Plant No. 6	2.3	2:1	variable 25 to 5	variable 10 to 5	variable 1 to 10	variable 1.4 to 3.3	250
Plant No. 6 to Plant No. 7	2.5	2:1	variable 25 to 5	variable 10 to 5	variable 1 to 10	variable 1.4 to 3.3	250
Plant No. 7 to Plant No. 8	3.0	2:1	variable 25 to 5	variable 10 to 5	variable 1 to 10	variable 1.4 to 3.3	250
Plant No. 8 to Plant No. 9	2.1	2:1	variable 25 to 5	variable 10 to 5	variable 1 to 10	variable 1.4 to 3.3	250
Plant No. 9 to Plant No. 10	1.5	2:1	variable 25 to 5	variable 10 to 6	variable 1 to 10	variable 1.4 to 3.0	250

Pipe Lines (northeast)—two
Type—Reinforced concrete
Length—3,700 feet each
Diameter—48 inches each
Capacity—45 second-feet each
Outlet elevations—125 feet

Pipe Lines (southwest)—two
Type—Reinforced concrete
Length—1,000 feet each
Diameter—66 inches each
Capacity—90 second-feet each
Outlet elevations—125 feet

laus River at the proposed Tulloch Dam, and conveyed through a tunnel to Littlejohns Creek at a point about a mile west of Goodwin Dam. The water would be diverted from Littlejohns Creek at a point about two miles downstream, and conveyed by canals and siphons to service areas in the Littlejohns, Calaveras, and Eastern Mokelumne Units, as well as to lands in Stanislaus County east of the Littlejohns Unit. In addition to serving irrigated lands, provision would also be made for diversion, treatment, and conveyance of a supplemental water supply to the City of Stockton. This diversion would be made from a small regulatory reservoir located on the main conveyance conduit at the San Joaquin-Stanislaus county line, about eight miles east of Linden. The project is hereinafter referred to as the "New Melones Project," and its principal features are designated the "New Melones Dam and Reservoir," "Stanislaus-San Joaquin Diversion," and "Flood Road-Stockton Diversion." General features at the project are shown on Plate 27, entitled "New Melones Project."

New Melones Dam and Reservoir. Construction of the New Melones Dam and Reservoir has been authorized by the Federal Government and by the State of California, but funds for construction of the project by the Corps of Engineers, United States Army, have not been appropriated by the Congress. Although the storage capacity considered for New Melones Reservoir for purposes of this bulletin is the same as that proposed by the Corps of Engineers, features of the dam and reservoir described herein were determined as the result of studies made in connection with the current investigation.

The proposed New Melones Dam would be a concrete gravity structure, with a gate-controlled overpour spillway. Stream bed elevation at the dam site is about 515 feet. The reservoir would inundate the existing Melones Dam and Reservoir. Irrigation and power releases of water would be made from the reservoir to the existing pressure tunnel serving the Melones Power Plant, and the installed power capacity of the power plant would be increased to accommodate the increased head and water supply. The new water supply developed by the project would then be diverted from the Stanislaus River at the proposed Tulloch Dam, a feature of the Tri-Dam Project proposed jointly by the Oakdale and South San Joaquin Irrigation Districts, and conveyed to the San Joaquin Area.

It was estimated that mean seasonal runoff of the Stanislaus River, from the 900 square miles of watershed above the New Melones dam site, is about 1,193,000 acre-feet. Based upon yield studies during the critical dry period which occurred from 1920-21 through 1934-35, together with topography of the dam site and cost analyses hereinafter discussed, a reservoir of 1,100,000 acre-foot storage capacity, with estimated new seasonal irrigation yield of 300,000 acre-feet, was chosen for purposes of cost estimates to be presented in this bulletin. Studies from which the yield was determined were based on the assumption that the principal adjudicated rights in the Stanislaus River Decree were valid, and, therefore, a diversion of water at rates up to 88 second-feet, when available, or about 50,000 acre-feet per season, would be made from the North Fork of the Stanislaus River through the Utica Canal, and that a diversion of water at rates up to 52 second-feet, when available, or about 30,000 acre-feet per season, would be made from the South Fork of the Stanislaus River to Tuolumne County. It was also assumed that the Tri-Dam Project, for the development of the Middle Fork and main stem of the Stanislaus River, would be constructed and in operation. The yield study for a reservoir at the New Melones site with 1,100,000 acre-foot storage capacity is included in Appendix K.

Studies were also conducted to determine the new irrigation yield from New Melones Reservoir under the added assumption that the ultimate water requirements in Calaveras and Tuolumne Counties would be largely met by water from the Stanislaus River. These estimated requirements, over and above the amount of the adjudicated rights on the North Fork and South Fork to Calaveras and Tuolumne Counties, are 57,000 acre-feet and 42,000 acre-feet per season, respectively. Development of the North Fork of the Stanislaus River by construction of a dam and reservoir at the Spicers Meadows site with a storage capacity of 62,000 acre-feet, and a dam and reservoir at the Ramsey site, with a storage capacity of 32,000 acre-feet, would yield about 53,000 acre-feet of water per season, which could serve Calaveras County. Conservation of water of the Middle and South Forks by construction of an enlarged Lyons Dam, creating storage capacity of 124,000 acre-feet, would yield about 51,000 acre-feet of water per season to serve Tuolumne County. Under these added assumptions, the new irrigation yield which could be developed by a New Melones Dam and Reservoir of 1,100,000 acre-foot storage capacity would be about 203,000 acre-feet per season.

In addition to the foregoing, other studies were conducted to determine the new irrigation yield of New Melones Reservoir operated coordinately with Woodward Reservoir on Simmons Creek, under the assumptions that the Tri-Dam Project would not be constructed, and that the adjudicated rights in the Stanislaus River Decree would prevail. The new yield was determined as the difference between the yield of the existing Melones and Woodward Reservoirs, as presently operated, and the yield under the assumed conditions. Based upon yield studies during the critical dry period which occurred from 1920-21 through 1935-36, a reservoir of 1,100,000 acre-foot storage capacity at the New Melones dam site, combined with Woodward Reservoir, would have a safe seasonal irrigation yield of about 710,000 acre-feet. The safe seasonal irrigation yield of the existing works is about 270,000 acre-feet. Therefore, the new safe irrigation yield from the proposed New Melones Reservoir, under such operation, would be about 440,000 acre-feet per season. These yield studies are included in Appendix K.

A topographic survey of the New Melones reservoir site up to an elevation of 740 feet was made by the Oakdale and South San Joaquin Irrigation Districts in 1921, and a map was drawn to a scale of 1 inch equals 200 feet, with a contour interval of 10 feet.

Topography above an elevation of 700 feet was ob-
ained from a survey made by the United States
Corps of Engineers at a scale of 1:6,000, and with a
ontour interval of 50 feet. A topographic survey of
he New Melones dam site up to an elevation of 1,100
eet was made by the Corps of Engineers in 1945,
nd a map was drawn to a scale of 1 inch equals 100
eet, with a contour interval of 10 feet. Storage ca-
pacities of New Melones Reservoir at various stages
f water surface elevation, based on the area-capacity
urves for the reservoir prepared by the Corps of
Engineers and dated September, 1953, are given in
Table 61.

TABLE 61

AREAS AND CAPACITIES OF NEW MELONES RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0	515	0	0
85	600	130	10,000
10	625	280	28,000
35	650	520	30,000
60	675	850	40,000
85	700	1,220	65,000
10	725	1,670	100,000
35	750	2,110	147,000
60	775	2,600	210,000
85	800	3,130	285,000
10	825	3,730	372,000
35	850	4,380	474,000
60	875	5,100	592,000
85	900	5,820	725,000
10	925	6,560	878,000
35	950	7,320	1,054,000
45	960	7,620	1,100,000
60	975	8,120	1,250,000
85	1,000	9,000	1,460,000

Based upon preliminary geological reconnaissance, he New Melones dam site is considered to be suitable or a concrete gravity dam of any height up to at east 500 feet. The dam site is underlain by a series of meta-volcanics, chiefly greenstones, with associated bands of slates and schists. The strike of the de-veloped schistosity is approximately at right angles o the stream course, and the dip is steeply upstream. In general, the rock is very hard and dense where fresh, but is cut into small blocks, often in the shape of rhombs, by a maze of joints occurring in many ets. The jointing is very strong and is probably per-sistent with depth. Numerous shear zones parallel he schistosity, and are apparently responsible for ome of the more prominent sharply defined draws. A small slide area involving only surface material occurs high on the left abutment, just upstream from he proposed dam axis. The relatively inactive Bostic Mountain fault, and a branch thereof, cross the Stanislaus River within a distance of a few hundred yards upstream from the dam site. The presence of hese faults should not materially affect the design of the dam, although much in the way of exploration of the fault areas should be conducted prior to construction at this site. Stripping, normal to the surface, of about 40 to 50 feet of rock from the abutments, and of about 30 feet of rock and talus from the narrow channel bottom, should be sufficient to prepare the foundation for a concrete gravity dam of between 400 and 500 feet in height. Concrete aggregates for the dam could either be crushed from the bedrock locally or imported to the site by truck from existing aggregates plants on the Stanislaus River downstream from Knights Ferry.

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A spillway could best be provided by discharging over the top of the dam. Protection of the river just downstream from the toe of the dam structure would have to be provided. The many joint sets, as well as the numerous shear and schistose zones in the rock, would be especially susceptible to erosion from water passing over the dam. Some additional protection to rock at the foot of the dam would be gained when the proposed Tulloch Reservoir, a feature of the Tri-Dam Project, was filled to capacity. This reservoir would raise stored water upon the base of the New Melones Dam and thus provide a water cushion for the spill.

The area which would be inundated by New Melones Reservoir includes a few small parcels of cultivated lands, worked-over mineral and gold-bearing gravel lands, and grazing lands. The reservoir would inundate the old town site of Melones, including the now abandoned mill site of the Carson Hill Gold Mine, three inactive small gold mines, 4 miles of transmission lines, 2.4 miles of telephone lines, a state highway crossing at Melones, a county bridge at Parrotts Ferry, and the existing Melones Dam and Reservoir.

As a result of yield studies, geologic reconnaissance, and preliminary economic analysis, a concrete gravity dam, 400 feet in height from stream bed to spillway lip, and with a crest elevation of 962 feet, was selected to illustrate estimates of cost of the New Melones Project. The dam would have a crest length of 1,195 feet, a crest width of 30 feet, and slopes of 0.05:1 upstream and 0.8:1 downstream.

The spillway would be of the overpour type, located in the center of the dam. The control structure would consist of an ogee weir, 180 feet in length, provided with three radial gates 45 feet high by 60 feet wide. The elevation of the spillway lip would be 915 feet. With the gates closed, the top of the gates would be at an elevation of 960 feet. The maximum depth of water above the spillway lip would be 45 feet, and an additional 2 feet of freeboard would be provided. The spillway would have a capacity of 172,000 second-feet with the three radial gates fully opened, required for an assumed maximum discharge of 190 second-feet per square mile of drainage area. The spillway would discharge into the Stanislaus River at the downstream toe of the dam.

Flood control outlets would consist of two 8-foot diameter steel conduits placed through the spillway section of the dam at an invert elevation of 656 feet. The flood control outlets, when augmented by flood releases through the irrigation outlets, discussed later, were designed to discharge a total of 12,000 second-feet under a head of 215 feet. Each of the flood control outlets would be controlled by two 6-foot by 8-foot high-pressure slide gates installed in tandem within the dam. An irrigation and power outlet would consist of a 12-foot diameter steel conduit extending through the bottom of the dam to connect with the tunnel from the existing Melones Reservoir to the existing power plant. This tunnel would serve to divert the flow of Stanislaus River during construction of New Melones Dam, and would later be plugged with concrete above the junction with the irrigation and power outlet. The irrigation and power outlet was designed to discharge 1,800 second-feet when the water surface in the reservoir would be at a minimum operating elevation of 730 feet. It would be controlled by a 14-foot by 22-foot Broome gate on the upstream face of the dam, and by a 108-inch diameter Howell-Bunger valve at the downstream face. Two irrigation outlets would be provided, consisting of 8-foot diameter steel conduits through the dam at an invert elevation of 656 feet, designed to discharge a total of 2,800 second-feet when the reservoir water surface was at a minimum operating elevation of 730 feet. The conduits would be controlled by 6-foot by 8-foot high-pressure slide gates within the dam, and 48-inch diameter needle valves at the downstream face.

In order to utilize the increased yield made available by New Melones Reservoir, the existing Melones Power Plant, located immediately downstream from the left abutment of the dam, would be enlarged from its present installed power capacity of 26,000 kilowatts to a capacity of 65,000 kilowatts. The enlarged plant would operate under a maximum head of 460 feet, and the present power house would be enlarged to provide space for the additional generating capacity. The dependable power capacity of the New Melones Power Plant would be about 39,000 kilowatts, and its average annual energy output would be about 269,000,000 kilowatt-hours. Based on studies made for "Engineering Report on Tri-Dam Project on Stanislaus River of Oakdale and South San Joaquin Irrigation Districts, prepared for California District Securities Commission," by the Division of Water Resources in December, 1952, the present Melones Power Plant has a dependable power capacity of 2,000 kilowatts, and its average annual energy output is 87,800,000 kilowatt-hours. Therefore, the dependable power capacity and average annual energy output creditable to the New Melones Project would be about 37,000 kilowatts and 181,200,000 kilowatt-hours, respectively. Waters released from the power plant would be returned to the Stanislaus River about 600 feet downstream from the toe of New Melones Dam.

Pertinent data with respect to general features of the New Melones Dam, Reservoir, and Power Plant, as designed for cost estimating purposes, are presented in Table 62.

TABLE 62

GENERAL FEATURES OF NEW MELONES DAM, RESERVOIR, AND POWER PLANT

Concrete Gravity Dam
- Crest elevation—962 feet
- Crest length—1,195 feet
- Crest width—30 feet
- Height, spillway lip above stream bed—400 feet
- Side slopes—0.05:1 upstream; 0.8:1 downstream
- Freeboard above top of radial gates—2 feet
- Elevation of stream bed—515 feet
- Volume of mass concrete—1,557,000 cubic yards

Reservoir
- Surface area to top of radial gates—7,600 acres
- Capacity to top of radial gates—1,100,000 acre-feet
- Drainage area—900 square miles
- Estimated mean seasonal runoff—1,193,000 acre-feet
- Estimated seasonal new irrigation yield—300,000 acre-feet
- Type of spillway—Overpour section in center of dam
- Spillway capacity—172,000 second-feet
- Flood control outlets—Two 8-foot diameter steel pipes through spillway section, combined capacity 12,000 second-feet
- Irrigation outlet—Two 8-foot diameter steel pipes through dam, capacity 2,800 second-feet at minimum reservoir elevation
- Irrigation and power outlet—12-foot diameter steel pipe connected to existing power tunnel, discharge 1,800 second-feet at minimum reservoir elevation

Power Plant
- Present power capacity—26,000 kilowatts
- Proposed power capacity—65,000 kilowatts

The capital costs of the New Melones Dam, Reservoir, and Power Plant, on a 3 per cent interest basis and with prices prevailing in April, 1953, were estimated to be about $47,617,000. The corresponding annual costs were estimated to be about $2,260,000. The resultant estimated unit cost of the 300,000 acre-feet per season of new irrigation water conserved by the project was about $7.50 per acre-foot. On a 4 per cent interest basis the estimated unit cost of the new water supply per season was about $8.80 per acre-foot.

The foregoing estimates are subject to reduction in the amount that the Federal Government would contribute toward the project in the interest of flood control. Based on information supplied by the Corps of Engineers, it was estimated that the average annual direct flood control benefits creditable to the New Melones Dam and Reservoir would be about $715,000. The estimates are also subject to reduction in the amount of the hydroelectric power revenues that might be assigned for payment of irrigation features of the project. Annual power revenues, based on unit values of $22 per kilowatt of dependable power capacity and 2.8 mills per kilowatt-hour of energy output, would amount to about $1,323,000. If a contribution equivalent to $715,000 annually were made by the Federal Government in the interest of flood control, and $1,323,000 in power revenues were realized from the project, the estimated unit cost of the new water supply at the dam would be about $0.75 per acre-foot on a 3 per cent interest basis, and about $2.00 per acre-foot on a 4 per cent interest basis.

Under the assumption that the ultimate water requirements of Calaveras and Tuolumne Counties would be met in part from the Stanislaus River, as previously discussed, and including the contribution by the Federal Government in the interest of flood control and the assignment of power revenues to the project, the resultant estimated unit cost of new water at the dam would be about $1.10 per acre-foot on a 3 per cent interest basis, and about $3.00 per acre-foot on a 4 per cent interest basis.

If the New Melones Dam and Reservoir were constructed, but the Tri-Dam Project were not built, and under the assumptions that the Federal Government would make a contribution in the interest of flood control and that power revenues were assigned to the project, the resultant estimated unit cost of new water from the New Melones Reservoir would be about $0.50 per acre-foot on a 3 per cent interest basis, and about $1.35 per acre-foot on a 4 per cent interest basis.

Estimated capital and annual costs of the New Melones Dam and Reservoir, and Power Plant, on a 3 per cent interest basis, are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
New Melones Dam and Reservoir	$39,185,000	$1,621,000
New Melones Power Plant	8,432,000	639,000
TOTALS	$47,617,000	$2,260,000

Stanislaus-San Joaquin Diversion. Under the plan considered, new irrigation water in the amount of 300,000 acre-feet per season would be released from New Melones Reservoir and diverted from the Stanislaus River at the proposed Tulloch Dam, about eight miles downstream from the New Melones site. The diverted water would be conveyed to the San Joaquin Area by means of a tunnel, canals, and siphons, which will be described in some detail hereinafter.

For purposes of this study, the seasonal yield developed by New Melones Reservoir, and delivered to the San Joaquin Area by the Stanislaus-San Joaquin Diversion, was allocated to the several units as follows: Littlejohns Unit, 115,000 acre-feet; Calaveras Unit, 50,000 acre-feet; and Eastern and Western Mokelumne Units, 50,000 acre-feet. An additional 85,000 acre-feet of water per season would be provided for irrigation of lands lying east of the Littlejohns Unit in Stanislaus County. Of the 50,000 acre-feet of seasonal yield allocated to the Calaveras Unit, 30,000 acre-feet would be treated and delivered to the City of Stockton for municipal and industrial uses. The diversion to Stockton will be described in a subsequent section entitled "Flood Road-Stockton Diversion."

As previously stated, the Stanislaus-San Joaquin Diversion would utilize Tulloch Dam and Reservoir for diversion of water released upstream from New Melones Reservoir. Tulloch Dam is a feature of the Tri-Dam Project, which is planned for construction in the near future by the South San Joaquin and Oakdale Irrigation Districts. The use of Tulloch Dam and Reservoir as diversion works under this plan would not impair their usefulness to the irrigation districts, as releases of new water would be made from New Melones Reservoir on an irrigation demand schedule and immediately diverted from Tulloch Reservoir.

Tulloch Dam would be a concrete gravity structure, with stream bed elevation of 360 feet. The dam would have a crest length of about 1,900 feet, and a height of 150 feet from stream bed to the maximum water surface elevation of 510 feet. The minimum water surface elevation would be 431 feet. Releases of water would be made from Tulloch Reservoir by means of two 7-foot diameter steel pipes extending through the dam near the right abutment. The outlet works would be protected by trash racks on the upstream face of the dam. In addition, a hydraulically operated 6-foot by 6-foot high-pressure slide gate would be provided on the upstream face of the dam over each pipe inlet for emergency closure. The elevation of the invert of the pipes at the entrance would be 431 feet. A hydraulically operated 72-inch diameter hollow jet valve would be provided at the downstream end of each pipe for regulation of releases. The flow in each of the two 7-foot diameter steel pipes would be directed into a single 12-foot diameter reinforced-concrete pipe by means of a concrete transition structure located immediately downstream from the control valves. This pipe would convey the water a distance of 650 feet, and would discharge into a canal with bottom elevation of 428 feet.

The design capacity of the conveyance conduit was based on the maximum monthly diversion demand, which occurs during July and amounts to 22 per cent of the total seasonal demand. However, the conduit capacity was increased to 25 per cent of the total seasonal demand to allow for short-term peaking in excess of the maximum monthly rate. The capacity of the Stanislaus-San Joaquin Diversion would decrease along its route, as releases would be made to the several service areas.

The initial section of the Stanislaus-San Joaquin Diversion would be a concrete-lined canal of trapezoidal section, with 1:1 side slopes, bottom width of 12 feet, depth of 10 feet, and freeboard of 2 feet. Its slope would be approximately 3.2 feet per mile, and the velocity would be about 5.7 feet per second. The capacity of the canal would be 1,250 second-feet. The ground along the proposed route of the canal is relatively steep and rocky. The water would be conveyed westerly a distance of 5,200 feet in the canal, to the portal of a tunnel through Table Mountain, which divides the watersheds of the Stanislaus River and Littlejohns Creek. The tunnel would be horseshoe in section, with a diameter of 16 feet. The bottom and lower portion of the sides of the tunnel would be concrete-lined. The tunnel would convey the water westerly a distance of 6,800 feet, and would discharge into Littlejohns Creek about four miles northeast of Knights Ferry, at an elevation of 412 feet. The stream bed elevation at this point is about 437 feet. It would be necessary, therefore, to excavate the channel of Littlejohns Creek down to an elevation of 412 feet. This excavation would continue downstream for a distance of 7,800 feet, to the point where the excavated channel would coincide with the natural stream bed. The slope of the excavated channel would be sufficiently steep to prevent silting. From this point the natural channel of Littlejohns Creek would be used as a conduit for conveyance of the water to a diversion dam, located about two miles north of Knights Ferry. The stream bed elevation at the diversion dam would be 325 feet. The flow in Littlejohns Creek would be divided at the diversion dam, with 185,000 acre-feet per season being diverted into a canal for conveyance to Stanislaus County and to the Calaveras and Eastern and Western Mokelumne Units, and 115,000 acre-feet being released down Littlejohns Creek for use in the Littlejohns Unit.

It was estimated that losses of water in conveyance and distribution of the 115,000 acre-feet per season of new irrigation yield assigned to the Littlejohns Unit would be about 20 per cent, leaving some 92,000 acre-feet for application to irrigated lands. Based on an indicated seasonal irrigation application of 6.0 acre-feet per acre to lands in the Littlejohns Unit, the new water supply could serve about 15,300 acres. It was estimated that seasonal consumptive use of water applied to probable crops in the Littlejohns Unit would amount to about 3.8 acre-feet per acre. The unconsumed portion of applied irrigation water, plus canal percolation losses, would, therefore, augment ground water supplies by some 56,400 acre-feet per season. In addition to eliminating progressive lowering of ground water levels, this new ground water supply could serve about 1,600 acres of irrigated lands.

As stated, 185,000 acre-feet of water per season would be diverted from Littlejohns Creek into a conduit to serve the remainder of the San Joaquin Area, and lands in Stanislaus County. The conduit would be designed with a capacity of 770 second-feet, and would consist principally of canal section. The water would be conveyed in a general northwesterly direction for a distance of about 27 miles, to a point on the Stanislaus-Calaveras county line about 2 miles south of Milton. Although water would be released along the route of the conduit to serve lands in Stanislaus County, the discharging capacity was considered to be 770 second-feet throughout this entire section for purposes of the cost estimates. The conduit from Littlejohns Creek to Milton would comprise 25.4 miles of concrete-lined canal and 1.4 miles of flume. The canal would be of trapezoidal section, with 1.5 : 1 side slopes, bottom width of 8 feet, depth of 8 feet and freeboard of 3 feet. Its slope would be approximately 1.7 feet per mile, and the velocity would be about 4.8 feet per second. The flume section would be of Lennon type, No. 300, with a diameter of 15.92 feet, and a slope of about 5.3 feet per mile. The elevation at the lower end of the conduit from Littlejohns Creek to Milton would be about 274 feet.

Lands in Stanislaus County would be served 85,000 acre-feet of water per season from the conduit between Littlejohns Creek and Milton. Based on a seasonal application to irrigated lands of 6.0 acre-feet per acre, some 14,200 acres could be served a surface supply.

The reach of conduit from Milton to the Calaveras River would convey 100,000 acre-feet of water per season to the Calaveras and Eastern and Western Mokelumne Units. The conduit route would roughly follow the 250-foot contour in a general northwesterly direction for a distance of about 22.6 miles, to a point about 6 miles east of Linden and 1 mile south of the Calaveras River, terminating in the northwest quarter of Section 3, Township 2 North, Range 9 East, M. D. B. & M. This reach of conduit was designed with a capacity of 420 second-feet, and would comprise principally canal section. Although releases of water to the Calaveras Unit would be made along the conduit route, the capacity throughout this entire reach was considered to be 420 second-feet for purposes of cost estimates. The canal section would total 20.9 miles in length, and would be concrete-lined and trapezoidal in section, with 1.5 : 1 side slopes, bottom width of 7 feet, depth of 6.4 feet, and freeboard of 2.6 feet. The slope of the canal would be approximately 1.5 feet per mile, and the velocity would be about 4 feet per second. The total length of flume would be about 1.7 miles, and would be of Lennon type, No. 252, with a diameter of 13.37 feet, and a slope of about 4.2 feet per mile. The elevation of the canal bottom at the lower end of this reach would be about 235 feet.

A small regulatory reservoir would be located on the conduit about 8 miles east of Linden, and about 3 miles south of the Calaveras River, on the San Joaquin-Stanislaus County line. This would serve as a storage and sedimentation reservoir for a municipal water supply for the City of Stockton. A seasonal release of 30,000 acre-feet of water would be made from he conduit to the reservoir at this point. The details of this diversion, and of a treatment plant and onveyance facilities, will be described in an ensuing ection entitled "Flood Road-Stockton Diversion."

An additional 20,000 acre-feet of water per season vould be diverted along the conduit route to serve gricultural lands in the Calaveras Unit. Assuming hat conveyance and distribution losses in serving hese lands would be 25 per cent of the gross diverion, about 15,000 acre-feet of water per season would e available for application to irrigated lands. On the asis of a seasonal irrigation application of 4.0 acreeet per acre, approximately 3,800 acres of lands in he Calaveras Unit could be served. The indicated easonal consumptive use of applied irrigation water o probable crops in the Calaveras Unit would be bout 2.2 acre-feet per acre. Based on this value, ercolation of unconsumed irrigation water, plus ercolation losses from local conveyance and distribuion canals, would augment ground water supplies in he Calaveras Unit by about 11,900 acre-feet per eason.

The conveyance conduit would cross the Calaveras River by means of a 72-inch diameter steel pipe iphon, about 1.8 miles in length. The siphon was deigned with a capacity of 210 second-feet, for coneyance of 50,000 acre-feet of water per season to the Eastern Mokelumne Unit. The siphon would termiate in the northwest quarter of Section 33, Township North, Range 9 East, M. D. B. & M., about 0.4 mile orth of State Highway 8. The invert elevation at this oint would be about 212 feet.

The water would be conveyed from the Calaveras River siphon in a northwesterly direction for about 2.5 miles to Bear Creek. The conduit would include anal and flume, and would have a capacity of 210 econd-feet. The concrete-lined canal would be trapeoidal in section, with a bottom width of 5 feet, side lopes of 1.5:1, depth of 5 feet, and freeboard of 2.2 eet. The slope of the canal would be about 1.6 feet er mile, and the velocity would be about 3.4 feet per econd. The total length of the canal in this reach ould be 11.8 miles. An additional 0.7 mile of flume ould be required. The flume would be of Lennon ype, No. 192, with a diameter of 10.19 feet, and a lope of about 4.2 feet per mile. The conduit would ischarge into a tributary of Bear Creek at the center f Section 35, Township 4 North, Range 8 East, I. D. B. & M., about 2.5 miles south of Clements. The levation of the bottom of the canal at this point ould be about 190 feet.

The natural channel of the tributary of Bear Creek ould be utilized as a conduit for about 2 miles, a point about 400 feet east of Atkins Road, where small diversion dam would be constructed. Of the),000 acre-feet of water per season released into the reek, 25,000 acre-feet would be allowed to by-pass the diversion dam and flow down Bear Creek to serve lands in the Eastern Mokelumne Unit lying south of the Mokelumne River. The remaining 25,000 acrefeet would be diverted and conveyed to the Mokelumne River.

Assuming a 25 per cent conveyance and distribution loss, some 18,700 acre-feet of water per season could be applied to lands lying south of the Mokelumne River. Based on an estimated seasonal application to irrigated lands of 3.0 acre-feet per acre, about 6,200 acres could be served a new surface supply. In addition, ground water supplies would be augmented by some 15,100 acre-feet, which would reduce progressive lowering of ground water levels in the area served.

The conveyance conduit from Bear Creek to the Mokelumne River would have a capacity of 105 second-feet, and would deliver 25,000 acre-feet of water per season to the Mokelumne River, where it would be available for diversion to the area north of that river. The conduit from Bear Creek to the Mokelumne River would comprise canal, flume, and pipe line. The total length of this conduit would be about 2.0 miles, and it would include 1.7 miles of canal, 0.15 mile of flume, and 0.15 mile of pipe line. The canal would be concrete-lined, and trapezoidal in section, with a bottom width of 4 feet, side slopes of 1.5:1, depth of 3.6 feet, and freeboard of 1.9 feet. The slope of the canal would be about 2.0 feet per mile, and the velocity would be 3.1 feet per second. The flume would be a Lennon type, No. 144, with a diameter of 7.65 feet, and a slope of 4.8 feet per mile. The steel pipe line would be 5 feet in diameter, and would convey the water beneath the railroad and highway and down the steep bluff to the flood plain of the Mokelumne River. The pipe line would discharge into a canal at the toe of the bluff. A 54-inch diameter hollow jet valve would be installed over the end of the pipe line to dissipate the 40 feet of static head on the line at that point.

Lands lying north of the Mokelumne River could be served with water, released into that river from the Bear Creek diversion, by means of the Lockeford Diversion which has been described under a previous project. Based on a seasonal irrigation application of water of 3.0 acre-feet per acre, approximately 8,300 acres could be served with this supply. In addition, ground water supplies would be augmented by some 11,700 acre-feet per season, which would reduce progressive lowering of ground water levels in the area served.

Pertinent data with respect to general features of the proposed Stanislaus-San Joaquin Diversion, as designed for cost estimating purposes, are presented in Table 63.

The estimated capital and annual costs of the Stanislaus-San Joaquin Diversion, on a 3 per cent interest

TABLE 63

GENERAL FEATURES OF STANISLAUS-SAN JOAQUIN DIVERSION

Outlet Works, Tulloch Dam	
Trash racks—on face of concrete gravity dam	
Emergency gates—two 6- x 6-foot high-pressure slide gates on face of dam	
Outlet pipe—two 7-foot diameter steel pipes, 120 feet in length	
Control valves—two 6-foot diameter hollow jet valves	
Transition—concrete, leading to one 12-inch diameter pipe	
Invert elevation, in feet, intake	431
outlet	429.5
Stanislaus River to Littlejohns Creek	
Concrete pipe	
Diameter, in feet	12
Length, in feet	650
Velocity, in feet per second	11
Head loss, in feet	1.2
Canal	
Type	trapezoidal, concrete-lined
Bottom width, in feet	12
Side slopes	1:1
Depth, in feet	10
Freeboard, in feet	2
Lining—concrete on downhill side, bottom, and portion of uphill side	
Slope, in feet per mile	3.22
Capacity, in second-feet	1,250
Velocity, in feet per second	5.7
Length, in feet	5,200
Tunnel	
Type	horseshoe
Diameter, in feet	16
Lining—concrete on bottom and small portion of sides	
Capacity, in second-feet	1,250
Length, in feet	6,800
Invert elevation, in feet, intake	425
outlet	412
Excavation of channel of Littlejohns Creek	
Bottom width, in feet	14
Side slopes	1:1
Lining	none
Bottom slope	0.0024
Maximum depth, in feet	25
Length, in feet	7,800
Invert elevation, in feet, beginning	412
end	393
Littlejohns Creek to Milton	
Canal	
Type	trapezoidal, concrete-lined
Bottom width, in feet	8
Side slopes	1.5:1
Depth, in feet	8
Freeboard, in feet	3
Slope, in feet per mile	1.73
Length, in miles	25.40
Capacity, in second-feet	770
Velocity, in feet per second	4.8
Flume	
Type	Lennon No. 300
Diameter, in feet	15.92
Length, in miles	1.36
Slope	0.001
Milton to Calaveras River	
Canal	
Type	trapezoidal, concrete-lined
Bottom width, in feet	7
Side slopes	1.5:1
Depth, in feet	6.4
Freeboard, in feet	2.6
Slope	0.00029
Length, in miles	20.88
Capacity, in second-feet	420
Velocity, in feet per second	4.0
Flume	
Type	Lennon No. 252
Diameter, in feet	13.37
Length, in miles	1.67
Slope	0.0008
Calaveras River Siphon	
Type	steel pipe
Diameter, in feet	6
Length, in miles	1.75
Maximum static head, in feet	120
Location—1.5 miles upstream from Bellota	
Capacity, in second-feet	210
Calaveras River to Bear Creek	
Canal	
Type	trapezoidal, concrete-lined
Bottom width, in feet	5
Side slopes	1.5:1
Depth, in feet	5
Freeboard, in feet	2.2
Slope	0.0003
Length, in miles	11.77
Capacity, in second-feet	210
Velocity, in feet per second	3.4
Flume	
Type	Lennon No. 192
Diameter, in feet	10.19
Length, in miles	0.72
Slope	0.0008
Bear Creek to Mokelumne River	
Canal	
Type	trapezoidal, concrete-lined
Bottom width, in feet	4
Side slopes	1.5:1
Depth, in feet	3.6
Freeboard, in feet	1.9
Slope	0.00038
Length, in miles	1.67
Capacity, in second-feet	105
Velocity, in feet per second	3.1
Flume	
Type	Lennon No. 144
Diameter, in feet	7.65
Length, in miles	0.15
Slope	0.0009
Pipe	
Type	steel
Length, in miles	0.15
Diameter, in feet	5
Hollow jet valve—54-inch diameter, discharging water from 5-foot diameter pipe into canal under static head of 40 feet	

basis, will be presented, by its principal component features, at the end of the section on the New Melones Project. The estimated annual unit costs of the new water allocated to each of the several service areas, based both on 3 per cent and 4 per cent interest rates, and including costs of New Melones Dam and Reservoir, are presented in the following tabulation. Detailed cost estimates of the Stanislaus-San Joaquin Diversion are presented in Appendix L.

	Allocated seasonal yield, in acre-feet	*Estimated annual unit cost per acre-foot*	
		3 per cent interest rate	*4 per cent interest rate*
Littlejohns Unit	115,000	$1.15	$2.50
Stanislaus County lands	85,000	2.10	3.60
Calaveras Unit	50,000	3.30	5.05
Eastern Mokelumne Unit			
South of Mokelumne River	25,000	4.70	6.70
North of Mokelumne River *	25,000	6.55	8.65

* Includes costs of the Lockeford Diversion.

Flood Road-Stockton Diversion. Studies were made of a plan to serve a supplemental water supply to the City of Stockton from the Stanislaus-San Joaquin Diversion. This water would be of excellent mineral quality, and would be suitable for municipal and industrial uses. Under the plan, 30,000 acre-feet of water per season would be released from the Stanislaus-San Joaquin Diversion conduit into a small reservoir, which would be located about 8 miles east of Linden. The reservoir would have a gross storage capacity of about 5,500 acre-feet, of which 3,000 acre-feet would be utilized. The reservoir would serve primarily as a sedimentation basin, but would also provide emergency storage for a period of about three weeks during the month of maximum demand. Water released from the reservoir would pass through a treatment plant located immediately below the reservoir. The treated water would then be conveyed by pipe line to a 17,000,000-gallon water storage tank located on Flood Road, about 3 miles east of Linden. From the storage tank the water would be conveyed by pressure pipe line to the City of Stockton, where it would be pumped into the city distribution system under pressure. This plan will hereinafter be referred to as the "Flood Road-Stockton Diversion," and its principal features are illustrated on Plate 27.

The sedimentation and storage reservoir would be created by construction of an earthfill dam, with a height of 40 feet, on an unnamed stream, one-half mile west of the San Joaquin-Stanislaus county line, at the center of Section 13, Township 2 North, Range 9 East, M. D. B. & M. The central impervious section of the dam would be blanketed on the upstream and downstream sides by pervious sections. The slope of the embankment would be 2.5:1 and its crest width would be 30 feet. As previously stated, the reservoir would have a usable storage capacity of 3,000 acre-feet, and the water surface would fluctuate between maximum and minimum elevations of about 240 feet and 230 feet, respectively.

The treatment plant would be located immediately downstream from the dam. Water would be released through the dam and conveyed to the treatment plant in a 48-inch diameter steel pipe. The treatment plant would have a capacity of 50,000,000 gallons per day, which was estimated to be the average daily consumption during the month of maximum demand. The plant would provide rapid sand filtration and chlorination. Water would be conveyed to 10 rapid sand filter units, with 2 filters each, each having an area of 620 square feet. For cost estimating purposes, it was assumed that the filters would be of reinforced-concrete construction, with a width of 20 feet, length of 31 feet, and a depth of 15 feet. The water would filter through a depth of 1.5 feet of graded sand and 2 feet of graded gravel. A portion of the filtered water would be pumped to a filter back-wash water tank. This tank would have a capacity of 150,000 gallons, and its bottom elevation would be at least 40 feet above the filters. The water would be chlorinated after leaving the filters, and before leaving the treatment plant. Removal of excessive turbidity of the water could be facilitated by adding alum and lime before filtration.

After chlorination, the water would be conveyed from the treatment plant, in a 48-inch diameter steel pipe line, in a westerly direction along Flood Road for a distance of about 5 miles to a water storage tank, located immediately south of Flood Road, in Section 19, Township 2 North, Range 9 East, M. D. B. & M. A storage capacity of 17,000,000 gallons would be required to provide sufficient regulation to compensate for fluctuation in daily peak demands. As designed for cost estimating purposes, the water storage tank would be square, with sides about 395 feet in length, and with a 15-foot depth of water. The gross area of the tank would be 156,000 square feet. The tank would be constructed partially below ground level, by excavation to a depth of 5 feet, and would be covered with a roof of timber construction for sanitary purposes. The walls, floor, and roof support columns would be of reinforced-concrete construction.

From the storage tank, the treated water would be conveyed in a 5-foot diameter steel pipe line about 17 miles in a general westerly direction to the City of Stockton. After leaving the storage tank, the pipe line would follow Flood Road in a westerly direction for 0.5 mile to its junction with Fine Road. The pipe line would then follow Fine Road in a southerly direction for 1.5 miles to the Milton Road intersection, where it would swing west, following Milton Road for a distance of about 9 miles to the Stockton Diverting Canal. The pipe line would then follow along the right bank of the diverting canal for about 5 miles, thence along Calaveras River for 2 miles to the intersection of Pacific Avenue and Brookside Road. From this terminus the water would be conveyed to 18 existing pumping and booster plants of the California Water Service Company, and would have a residual pressure of from 10 to 20 pounds per square inch. The distri-

TABLE 64

GENERAL FEATURES OF FLOOD ROAD-STOCKTON DIVERSION

Diversion Dam and Auxiliary Dam	
Crest elevation, in feet	244
Crest width, in feet	30
Height, spillway lip above stream bed, in feet	35
Side slopes	2.5:1
Freeboard above spillway lip, in feet	4
Elevation of stream bed, in feet	205
Volume of fill, in cubic yards	123,000
Treatment Works	
Filtration plant, capacity in million gallons per day	50
Storage tank, capacity in million gallons	17
Chemical building, capacity in million gallons per day	50
Conveyance System	
Filtration plant to storage tank	
Type	steel pipe
Diameter, in feet	4
Length, in miles	6.06
Maximum static head, in feet	80
Capacity, in second-feet	75
Storage tank to Stockton	
Type	steel pipe
Diameter, in feet	5
Length, in miles	17.61
Maximum static head, in feet	143
Capacity, in second-feet	90
Distribution System	
Reinforced-concrete cylinder pipe	
36-inch, length, in feet	13,600
30-inch, length, in feet	27,000
24-inch, length, in feet	14,200
Welded steel pipe	
22-inch, length, in feet	1,100
20-inch, length, in feet	20,400
16-inch, length, in feet	11,200
14-inch, length, in feet	17,800
12-inch, length, in feet	12,800
10-inch, length, in feet	17,100
Booster Pumping Plant	
Pumps	
Type	horizontal, centrifugal, mixed flow
Number	4
Two pumps with capacity of 4 million gallons per day	
Two pumps with capacity of 3 million gallons per day	
Installed pumping capacity, in million gallons per day	14
Maximum pumping demand, in million gallons per day	10
Maximum pumping pressure head, in feet	150
Motors	
Type	all-weather
Number	4
Two 125-horsepower motors	
Two 100-horsepower motors	

bution system would be identical to that described heretofore under the heading "Delta-Stockton Diversion Project."

Pertinent data with respect to the principal features of the Flood Road-Stockton Diversion, as designed for cost estimating purposes, are presented in Table 64.

The capital cost of the Flood Road-Stockton Diversion, on a 3 per cent interest basis and with prices prevailing in April, 1953, was estimated to be $10,457,000. Corresponding annual costs of the diversion were estimated to be $546,000. The resultant average annual unit cost of the 30,000 acre-feet of supplemental water would be about $18.20 per acre-foot. On a 4 per cent interest basis, the annual unit cost of the water would be about $20.90 per acre-foot.

The foregoing estimated costs apply only to the Flood Road-Stockton Diversion feature of the New Melones Project, and do not include the portion of the costs of New Melones Dam, Reservoir, and Power Plant, and the Stanislaus-San Joaquin Diversion, which would be properly allocable to the Flood Road-Stockton Diversion. The estimated unit cost of water delivered to the regulatory reservoir site, at the intake of the Flood Road-Stockton Diversion, would be $3.30 and $5.05 per acre-foot, based on interest rates of 3 per cent and 4 per cent, respectively. The total annual unit cost per acre-foot of the water supply delivered into the City of Stockton distribution system, would therefore be about $21.50 on a 3 per cent interest basis, and $25.95 on a 4 per cent interest basis.

Estimated capital and annual costs of the Flood Road-Stockton Diversion on a 3 per cent interest basis are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	Estimated Costs	
	Capital	*Annual*
Dam and reservoir	$189,000	$8,000
Treatment works	2,621,000	193,000
Conveyance system	5,245,000	231,000
Distribution system	2,402,000	114,000
TOTALS	$10,457,000	$546,000

Summary of Costs of New Melones Project. The estimated capital and annual costs of the New Melones Project are summarized by its principal features in Table 65. There is also shown in Table 65 a summary of the annual unit costs of the new yield allocated to the several service areas. These estimated costs are based on a 3 per cent interest rate. Detailed estimates of cost of the New Melones Project are presented in Appendix L.

Summary of Plans for Water Supply Development

The several plans for initial development of supplemental water supplies for the San Joaquin Area, which were given consideration in the current investigation, have been described in some detail in the preceding sections. Table 66 presents a summary comparison of the various projects.

TABLE 65

SUMMARY OF ESTIMATED COSTS OF NEW MELONES PROJECT

Item	Capital cost	Annual cost	Allocation of seasonal yield, in acre-feet	Cost per acre-foot	Cost per acre-foot to service area
New Melones Dam, Reservoir, and Power Plant	$47,617,000	[a]$222,000		$0.75	
Stanislaus-San Joaquin Diversion					
Stanislaus River to Littlejohns Creek	3,006,000	124,000		0.40	
Cost to Littlejohns Unit			115,000		$1.15
Littlejohns Creek to Milton	3,978,000	175,000		0.95	
Cost to lands in Stanislaus County			85,000		2.10
Milton to Calaveras River	2,728,000	120,000		1.20	
Cost to Calaveras Unit			[b]50,000		3.30
Calaveras River to Bear Creek	1,592,000	70,000		1.40	
Cost to Eastern Mokelumne Unit lands south of Mokelumne River			25,000		4.70
Bear Creek to Mokelumne River	177,000	8,000		0.30	
Lockeford Diversion	401,000	38,000		1.50	
Cost to Eastern Mokelumne Unit lands north of Mokelumne River			25,000		6.55
Subtotals, Stanislaus-San Joaquin Diversion	$59,499,000	$757,000			
Flood Road-Stockton Diversion	10,457,000	546,000		18.20	
Cost to City of Stockton			[b]30,000		21.50
TOTALS, NEW MELONES PROJECT	$69,956,000	$1,303,000	300,000		

[a] Based on assumed federal flood control contribution equivalent to an annual payment of $715,000, and an annual power revenue of $1,323,000.
[b] 30,000 acre-feet allocated to City of Stockton.

SUMMARY COMPARISON OF PLANS AND COST ESTIMATES FOR WATER SUPPLY DEVELOPMENT FOR SAN JOAQUIN AREA

Project	Source of water supply	Purpose and general method of water service	Type and height of dam	Reservoir storage capacity, in acre-feet	Conduit capacity, in second-feet	New installed hydro-electric power capacity, in kilowatts	New yield, in acre-feet per season	Costs (3 per cent interest basis)			Annual flood control benefits	New annual power revenues	Net annual costs	
								Capital	Annual					
									Total	Per acre-foot of new seasonal yield			Total	Per acre-foot of new seasonal yield
Folsom South Canal	American River	Irrigation, gravity			1,300		303,000	$12,300,000	[a]$953,000	[a]$3.20			[a]$953,000	[a]$3.20
Delta-Mokelumne River Diversion	Delta	Irrigation, pump			250		60,000	1,784,000	[b]191,000	[b]3.20			[b]251,000	[b]3.20
Mokelumne River	Mokelumne River	Irrigation, pump			250		31,000	651,000	64,000	2.10			64,000	2.10
Mehrten	Mokelumne River	Irrigation, pump	Earthfill, 85 feet	50,000	50		13,700	4,007,000	183,000	13.30			183,000	13.30
Camanche	Mokelumne River	Irrigation, pump	Earthfill, 130 feet	212,000	150	4,000	52,000	12,528,000	600,000	11.50		$105,000	495,000	9.50
Middle Bar	Mokelumne River	Irrigation, pump	Concrete gravity, 190 feet	46,500	50	10,000	11,000	6,995,000	380,000	34.50		268,000	112,000	10.20
Railroad Flat	Mokelumne River	Irrigation, pump	Earthfill, 339 feet	80,000	85		20,000	14,178,000	594,000	29.70			594,000	29.70
Ione	Dry Creek	Irrigation, gravity	Earthfill, 55 feet	40,000	85		21,000	2,844,000	122,000	5.80			122,000	5.80
Irish Hill	Dry Creek	Irrigation, gravity	Earthfill, 150 feet	43,500	85		20,000	3,844,000	167,000	8.35			167,000	8.35
Delta-Stockton Diversion	Delta	Municipal, pump			87		30,000	12,442,000	[b]906,000	[b]30.20			[b]936,000	[b]30.20
New Hogan	Calaveras River	Irrigation, gravity	Earthfill, 201 feet	315,000	210		48,000	10,364,000	447,000	9.30	$320,000		127,000	2.65
Delta-Littlejohns Diversion	Delta	Irrigation, pump			250		60,000	1,614,000	[b]282,000	[b]4.70			[b]342,000	[b]4.70
New Melones [a]														
At dam	Stanislaus River	Irrigation, gravity	Concrete gravity, 462 feet	1,100,000		39,000	300,000	47,617,000	2,260,000	7.50	715,000	1,323,000	222,000	0.75
In Littlejohns Unit							115,000							1.15
In Stanislaus County							85,000							2.10
In Calaveras Unit							[d]50,000							3.30
In Eastern Mokelumne Unit														
South of Mokelumne River							25,000							4.70
North of Mokelumne River							25,000							6.55
In City of Stockton							[d]30,000							21.50

[a] Includes assumed cost of $1.00 per acre-foot for water delivered to intake of Folsom South Canal.
[b] Does not include cost for firming up the diverted supply from the Delta with water from either the Feather River or Folsom Projects.
[c] Assumes Tri-Dam Project constructed and adjudicated rights on Stanislaus River valid.
[d] 30,000 acre-feet allocated to City of Stockton.

CHAPTER V

SUMMARY OF CONCLUSIONS

As a result of field investigation and analysis of available data on the water resources and water problems of the San Joaquin Area, and on the basis of the estimates and assumptions discussed hereinbefore, the following conclusions are made:

1. The present basic water problems in the San Joaquin Area are manifested in progressive perennial lowering of ground water levels and in the threat of attendant degradation of the mineral quality of the ground water.

2. Elimination of the foregoing problems, prevention of their recurrence in the future, irrigation of irrigable lands not presently served with water, and provision for anticipated future urban and industrial growth, will require the further development of water supplies available to the San Joaquin Area in tributary streams and in the Sacramento-San Joaquin Delta, or the importation of water supplies from other potential sources, or some combination thereof.

3. The present principal sources of water supply of the San Joaquin Area are direct precipitation, and runoff from the highly productive tributary drainage areas of the Sierra Nevada. There are no significant imports or exports of water. The weighted mean seasonal depth of precipitation on the area is about 15.4 inches, and direct precipitation contributes water in the mean amount of about 468,000 acre-feet per season. Mean seasonal natural flow of streams tributary to the area is about 1,160,000 acre-feet. Actual seasonal surface inflow to and outflow from the San Joaquin Area during the base period from 1939-40 through 1950-51, reflecting impairments by diversion, storage, import, export, and consumptive use of water caused by development, were about 1,022,000 acre-feet and 870,000 acre-feet, respectively.

4. The surface water supplies of the San Joaquin Area are of excellent mineral quality, and well suited from that standpoint for irrigation and other beneficial uses. Ground water of good mineral quality occurs generally throughout the area, except in certain localities adjacent to the Delta where some wells have encountered highly saline ground water.

5. The ground water basin underlying the San Joaquin Area, with a storage capacity of about 4,150,000 acre-feet between the levels of 25 and 200 feet below the ground surface, functions as a natural regulatory reservoir for a portion of the presently available water supply. At the present time about 80 per cent of the lands irrigated in the area are served with water pumped from this reservoir, and the gross extraction of ground water in 1948-49 was about 381,000 acre-feet. Satisfactory wells with yields sufficient for irrigation purposes may be developed in all portions of the San Joaquin Area.

6. Hydraulic gradients in the plane of ground water at the present time, considered equivalent to the average existing during the three-year period from 1949-50 through 1951-52, result in a seasonal excess of subsurface inflow over subsurface outflow from the Eastern Mokelumne, Calaveras, and Littlejohns Units of about 10,000 acre-feet, 36,000 acre-feet, and 51,000 acre-feet, respectively, which water constitutes an important source of replenishment to the ground water basin. The present excess of subsurface outflow from the Western Mokelumne Unit over subsurface inflow is about 32,000 acre-feet per season.

7. Safe seasonal yield of the ground water basin underlying the San Joaquin Area, with maintenance of average ground water levels prevailing during the period from 1949-50 through 1951-52, is about 266,000 acre-feet, distributed among the several units as follows: Western Mokelumne Unit, 55,000 acre-feet; Eastern Mokelumne Unit, 61,000 acre-feet; Calaveras Unit, 80,000 acre-feet; and Littlejohns Unit, 70,000 acre-feet. Present net seasonal extraction of water from the ground water basin is about 363,000 acre-feet, distributed among the several units as follows: Western Mokelumne Unit, 55,000 acre-feet; Eastern Mokelumne Unit, 89,000 acre-feet; Calaveras Unit, 98,000 acre-feet; and Littlejohns Unit, 121,000 acre-feet.

8. Because of the continuing development and extensive use of ground water in the San Joaquin Area, a substantial cone of depression exists in the ground water plane, and, with exception of the Western Mokelumne Unit, ground water levels generally are falling. The weighted average changes in levels of ground water in the Western Mokelumne, Eastern Mokelumne, Calaveras, and Littlejohns Units between 1939-40 and 1951-52 have amounted to about plus 0.1 foot, minus 9.2 feet, minus 15.7 feet, and minus 16.6 feet, respectively.

9. Approximately 20 per cent of the lands under water service in the San Joaquin Area are presently supplied irrigation water diverted from rivers or streams. Irrigated lands utilizing such surface water are principally served from works owned by organized water service agencies. During 1951-52 there were approximately 38,600 acres irrigated with a supply from surface sources, of which about 25,500 acres were in the Western Mokelumne Unit.

10. There are some 340 applications to appropriate water from streams in or tributary to the San Joaquin Area filed with the Division of Water Resources, not including appropriative rights initiated prior to December 19, 1914, riparian rights, correlative rights of overlying owners in ground water basins, nor prescriptive rights which may have been established on either surface streams or ground water basins. Rights to the use of waters in and tributary to the area have never been the subject of comprehensive adjudication wherein the right of each user has been determined as against that of each and every other user. In the absence of such adjudication, no right has been established conclusively beyond attack by anyone. However, certain rights to store and divert waters of the Mokelumne and Stanislaus Rivers have been the subject of court decrees and private agreements. Approximately 40 dams on streams in or tributary to the area are under supervision of the State as regards safety.

11. At the present time a net area of approximately 189,900 acres is irrigated in the San Joaquin Area, distributed among the several units as follows: Western Mokelumne Unit, 50,800 acres; Eastern Mokelumne Unit, 52,500 acres; Calaveras Unit, 44,500 acres; and Littlejohns Unit, 42,100 acres. It is probable that the ultimate land use pattern will include a net area of about 275,000 acres of irrigated land, distributed among the several units as follows: Western Mokelumne Unit, 56,000 acres; Eastern Mokelumne Unit, 88,000 acres; Calaveras Unit, 59,000 acres; and Littlejohns Unit, 72,000 acres.

12. Of the total amount of water, including rainfall, consumptively used in the San Joaquin Area at the present time, more than 70 per cent is consumed in the production of irrigated crops. Dry-farmed and fallow lands, native vegetation, and lands devoted to miscellaneous uses including urban, consume the remainder. At the present time the total mean seasonal consumptive use of water in the area is about 837,000 acre-feet, distributed among the several units as follows: Western Mokelumne Unit, 190,000 acre-feet; Eastern Mokelumne Unit, 219,000 acre-feet; Calaveras Unit, 201,000 acre-feet; and Littlejohns Unit, 227,000 acre-feet.

13. Under conditions of ultimate development the total mean seasonal consumptive use of water will probably increase to about 1,122,000 acre-feet, distributed among the several units as follows: Western Mokelumne Unit, 224,000 acre-feet; Eastern Mokelumne Unit, 317,000 acre-feet; Calaveras Unit, 235,000 acre-feet; and Littlejohns Unit, 346,000 acre-feet.

14. The present requirement for supplemental water in the San Joaquin Area, in order to prevent progressive perennial lowering of ground water levels and to eliminate the threat of attendant degradation of mineral quality of the ground water, is about 97,000 acre-feet per season, distributed among the several units as follows: Western Mokelumne Unit, none; Eastern Mokelumne Unit, 29,000 acre-feet; Calaveras Unit, 18,000 acre-feet; and Littlejohns Unit, 50,000 acre-feet. To the extent that water is consumptively used in and exported from tributary drainage basins, the water supply available to the San Joaquin Area is correspondingly reduced. Thus, an increase in the amount of such use and export would increase the supplemental water requirement over the foregoing estimate, which was based on the amount of water historically available to the area during the base period.

15. Under ultimate conditions of development the requirement for supplemental water in the San Joaquin Area probably will increase to about 382,000 acre-feet per season, distributed among the several units as follows: Western Mokelumne Unit, 34,000 acre-feet; Eastern Mokelumne Unit, 127,000 acre-feet; Calaveras Unit, 52,000 acre-feet; and Littlejohns Unit, 169,000 acre-feet.

16. Major features of The California Water Plan, which is presently being formulated under direction of the State Water Resources Board, could provide water to meet all or a portion of the probable ultimate supplemental requirement of the San Joaquin Area. The Feather River Project, an adopted feature of The California Water Plan, could accomplish this purpose by release of water conserved in Oroville Reservoir to supplement existing supplies in the Sacramento-San Joaquin Delta, and by pumped diversion of the firmed water from the Delta to the San Joaquin Area. It has been estimated that cost of such a supply would be about $2.50 per acre-foot in the Delta. The Folsom Project, providing regulatory storage on the American River, could likewise meet all or a portion of the probable ultimate supplemental requirement of the San Joaquin Area by conveyance of water conserved in Folsom Reservoir to the area by gravity conduit, or by release of the water to supplement existing supplies in the Sacramento-San Joaquin Delta and by the pumped diversion of the firmed water from the Delta to the San Joaquin Area. Estimated costs of such a supply, on a three per cent interest basis, would be about $3.20 per acre-foot if delivered by gravity to the area, or about $1.00 per acre-foot in the Delta.

17. It is feasible from an engineering standpoint to so regulate and conserve the flood flows of Dry Creek and the Mokelumne and Calaveras Rivers, the principal streams tributary to the San Joaquin Area, as to yield sufficient new water to meet the present supplemental requirement of the area and to provide some capacity for future growth in the requirement. However, such new water supplies would be insufficient to meet the probable ultimate supplemental requirement of the area. Furthermore, these streams are the

natural sources of water supply to meet the probable ultimate supplemental requirements in certain mountain and foothill service areas, and the Mokelumne River is presently under consideration to supply additional export water for municipal purposes in the San Francisco Bay area. Satisfaction of these requirements would impair the feasibility of projects on these streams for the benefit of the San Joaquin Area.

18. The potential new water supply which could be practicably developed from the Cosumnes River is inadequate to satisfy probable ultimate supplemental water requirements in the mountain and foothill service areas for which it is a natural source of supply. However, sufficient water could be imported from the South Fork of the American River to augment the developed local supplies and meet the ultimate supplemental requirements. Under such circumstances, little or no potential yield would remain for development in the Cosumnes River for possible utilization in the San Joaquin Area.

19. The potential new water supply which could be practicably developed from Dry Creek is inadequate to satisfy probable ultimate supplemental water requirements in the mountain and foothill service areas for which it is a natural source of supply. The ultimate supplemental requirements of these service areas could be most practicably satisfied by water imported from the American, Cosumnes, and Mokelumne Rivers, augmented by the developed local supplies within the Dry Creek watershed. Under such circumstances, a moderate amount of potential yield would remain for development in Dry Creek for possible utilization in the San Joaquin Area.

20. The potential new water supply which could be practicably developed from the Mokelumne River could satisfy probable ultimate supplemental water requirements in the mountain and foothill service areas for which it is a natural source of supply. However, under such circumstances, little or no potential yield would remain for development in the river for further utilization in the San Joaquin Area and for further export to other areas. Furthermore, adjustments would probably be required with present downstream users of Mokelumne River water.

21. The potential new water supply which could be practicably developed from the Calaveras River is inadequate to satisfy probable ultimate supplemental water requirements in the mountain and foothill service areas for which it is a natural source of supply. However, sufficient water could be imported from the Stanislaus River to augment the developed local supplies and meet the ultimate supplemental requirements. Under such circumstances, little or no potential yield would remain for development in the Calaveras River for possible utilization in the San Joaquin Area.

22. The potential new water supply which could be practicably developed from the Stanislaus River could satisfy probable ultimate supplemental water requirements in the mountain and foothill service areas for which it is a natural source of supply, if augmented by new water supplies developed from the Calaveras River. Under such circumstances, a substantial amount of potential yield would remain for development in the Stanislaus River for possible utilization in the San Joaquin Area and for possible export to other areas.

23. Under the Delta-Mokelumne River Diversion Project, new irrigation water sufficient to meet the present supplemental requirement in the Eastern Mokelumne Unit, together with additional water for growth in the requirement for a number of years in the future, could be developed by construction of facilities for pumping water, firmed by either the Feather River or Folsom Projects, directly from the Sacramento-San Joaquin Delta, and by construction of facilities for conveyance to and distribution of the firmed water in the irrigation system of the Woodbridge Irrigation District. In exchange, an equal amount of water now served the district would be diverted by pumps from the Mokelumne River to serve irrigable lands in the Eastern Mokelumne Unit. Cost estimates indicate that under this project the average annual cost of the new water in the service areas would be about $3.20 per acre-foot, on a three per cent interest basis, not including costs for firming the delta water.

24. Under the Mokelumne River Project, new irrigation water to more than meet the present supplemental requirement in the Eastern Mokelumne Unit could be developed by construction of facilities for pumping surplus water directly from the Mokelumne River, and conveyance of the pumped water to service areas in the unit. Cost estimates indicate that under this project the annual cost of new water in the service area would be about $2.10 per acre-foot on a three per cent basis, not including costs of the surface distribution system, nor of the duplicate system of standby ground water pumping wells.

25. Under the Mehrten Project, new irrigation water sufficient to meet a portion of the present supplemental requirement in the Eastern Mokelumne Unit could be developed by construction of a dam and reservoir on the Mokelumne River at the Mehrten site, and facilities for diversion and conveyance of the conserved water to service areas in the unit. Cost estimates indicate that under this project the average annual cost of the new water in the service areas would be about $13.30 per acre-foot, on a three per cent interest basis.

26. Under the Camanche Project, new irrigation water sufficient to meet the present supplemental requirement in the Eastern Mokelumne Unit, together with additional water for growth in the requirement for a number of years in the future, and new hydroelectric power, could be developed by construction of

a dam and reservoir on the Mokelumne River at the Camanche site, a hydroelectric power plant below the dam, and facilities for diversion and conveyance of the conserved water to service areas in the unit. New irrigation water could also be provided for use in the Western Mokelumne Unit for anticipated future growth in its water requirement. Cost estimates indicate that under this project the average annual costs of water in service areas in the Western and Eastern Mokelumne Units would be about $8.70 and $10.20 per acre-foot, respectively, on a three per cent interest basis. These estimates include credit for power revenues anticipated from the project.

27. Under the Middle Bar Project, new irrigation water sufficient to meet a portion of the present supplemental requirement in the Eastern Mokelumne Unit, and new hydroelectric power, could be developed by construction of a dam and reservoir on the Mokelumne River at the Middle Bar site, a hydroelectric power plant below the dam, and facilities for diversion and conveyance of the conserved water to service areas in the unit. Cost estimates indicate that under this project the average annual cost of the new water in the service areas would be about $10.20 per acre-foot, on a three per cent interest basis. This estimate includes credit for power revenues anticipated from the project.

28. Under the Railroad Flat Project, new irrigation water sufficient to meet a portion of the present supplemental requirement in the Eastern Mokelumne Unit could be developed by construction of a dam and reservoir on the Mokelumne River at the Railroad Flat site, diversion of flood water from the Middle Fork of the Mokelumne River to the reservoir, and construction of facilities for diversion and conveyance of the conserved water to service areas in the unit. Cost estimates indicate that under this project the average annual cost of the new water in the service areas would be about $29.70 per acre-foot, on a three per cent interest basis.

29. Under the Ione Project, new irrigation water sufficient to meet the present supplemental requirement in the portion of the Eastern Mokelumne Unit lying north of the Mokelumne River, together with additional water for a growth in the requirement of this service area for a number of years in the future, could be developed by construction of a dam and reservoir on Dry Creek at the Ione site, and facilities for diversion and conveyance of the conserved water to the service area. Cost estimates indicate that under this project the average annual cost of the new water in the service area would be about $5.80 per acre-foot, on a three per cent interest basis.

30. Under the Irish Hill Project, new irrigation water sufficient to meet the present supplemental requirement in the portion of the Eastern Mokelumne Unit lying north of the Mokelumne River, together with additional water for growth in the requirement of this service area for a number of years in the future, could be developed by construction of a dam and reservoir on Dry Creek at the Irish Hill site, diversion of flood water from Sutter Creek to the reservoir, and construction of facilities for diversion and conveyance of the conserved water to the service area. Cost estimates indicate that under this project the average annual cost of the new water in the service area would be about $8.35 per acre-foot, on a three per cent interest basis.

31. Under the Delta-Stockton Diversion Project, new municipal water sufficient to meet the present supplemental requirement in the Calaveras Unit, together with additional water for growth in requirements for a number of years in the future, both in the Calaveras Unit and the southerly portion of the Western Mokelumne Unit, could be developed by construction of facilities for pumping water, firmed by either the Feather River or Folsom Projects, directly from the Sacramento-San Joaquin Delta, and by construction of facilities for treatment and conveyance to and distribution of the firmed water in the existing water system serving the City of Stockton and environs. Cost estimates indicate that under this project the average annual cost of the new treated water distributed in the service area would be about $30.20 per acre-foot, on a three per cent interest basis, not including the cost for firming up the delta water.

32. Under the New Hogan Project, new irrigation water sufficient to meet the present supplemental requirement in the Calaveras Unit and a portion of the present supplemental requirement in the Littlejohns Unit, together with additional water for growth of the requirement in the Calaveras Unit for a number of years in the future, and substantial flood control, could be developed by construction of a dam and reservoir on the Calaveras River at the site of the existing Hogan Dam, and facilities for diversion and conveyance of the conserved water to the service areas. Cost estimates indicate that under this project the average annual cost of the new water in the service areas would be about $2.65 per acre-foot, on a three per cent interest basis. This estimate includes credit for anticipated federal contribution in the amount of the flood control benefits.

33. Under the Delta-Littlejohns Diversion Project, new irrigation water sufficient to meet the present supplemental requirement in the Littlejohns Unit, together with additional water for some growth of the requirement in the future, could be developed by construction of facilities for pumping water, firmed by either the Feather River or Folsom Projects, directly from the Sacramento-San Joaquin Delta, and by construction of facilities for conveyance of the firmed water to service areas in the unit. Cost estimates indicate that under this project the average

annual cost of the new water in the service areas would be about $4.70 per acre-foot, on a three per cent interest basis, not including the cost for firming up the delta water.

34. Under the New Melones Project, new water sufficient to meet the present supplemental requirement in the San Joaquin Area, together with additional water for growth in the requirement for a number of years in the future, new hydroelectric power, and substantial flood control, could be developed by construction of a dam and reservoir on the Stanislaus River near the site of the existing Melones Dam, a hydroelectric power plant below the new dam, and facilities for diversion and conveyance of the stored water to the area. Assuming that the Tri-Dam Project will be constructed, that adjudicated water rights on the Stanislaus River are valid and in effect, cost estimates indicate that under this project the annual cost of the new water in Stanislaus County, Littlejohns Unit, Calaveras Unit, south of the Mokelumne River in the Eastern Mokelumne Unit, north of the Mokelumne River in the Eastern Mokelumne Unit, and in the City of Stockton would be about $2.10 per acre-foot, $1.15 per acre-foot, $3.30 per acre-foot, $4.70 per acre-foot, $6.50 per acre-foot, and $21.50 per acre-foot, respectively, on a three per cent interest basis. This estimate includes credits for anticipated federal contribution in the amount of the flood control benefits and for anticipated power revenues.

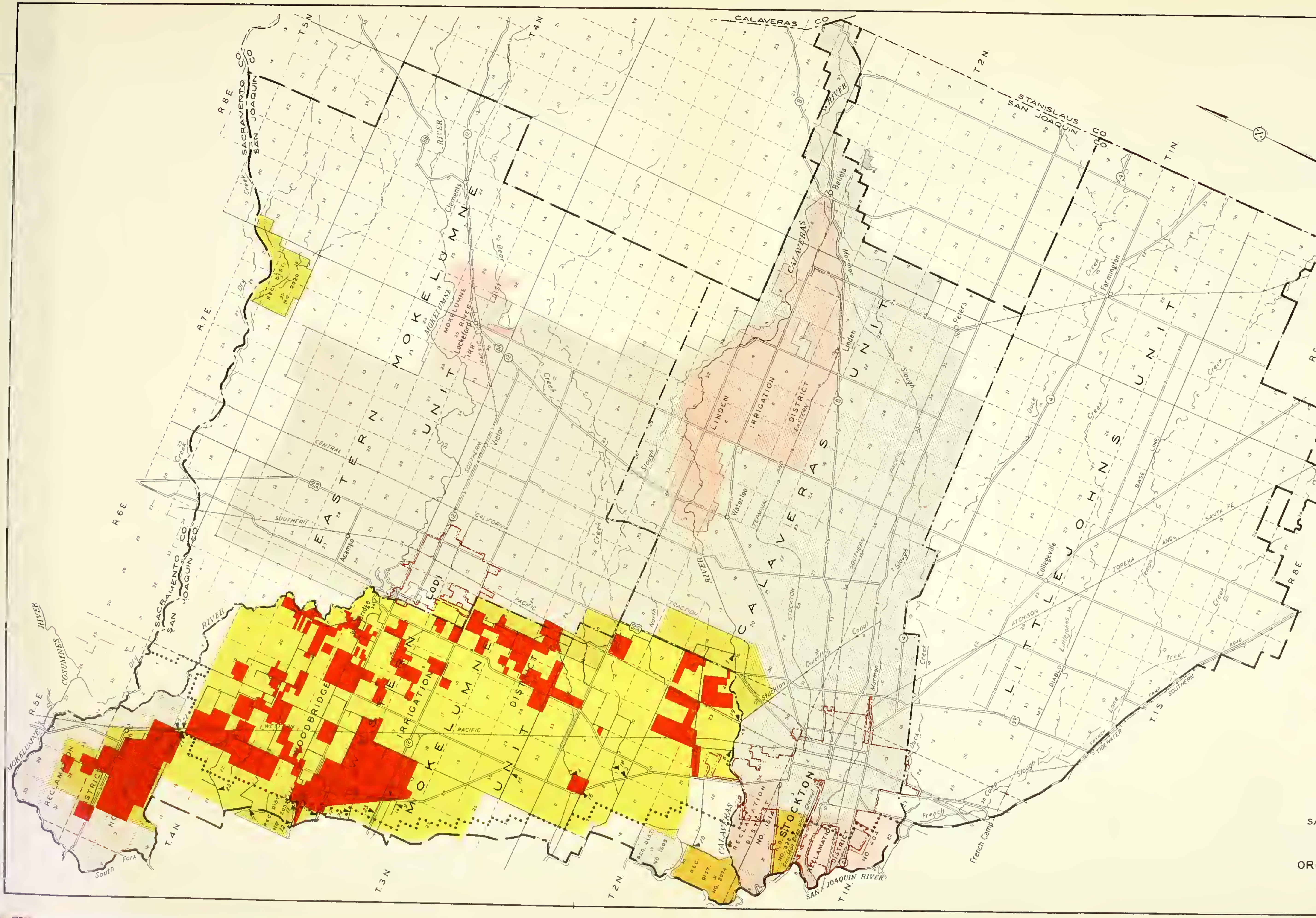
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

LOCATION OF SAN JOAQUIN AREA
1953

SCALE OF MILES
50 0 50 100

PLATE 2



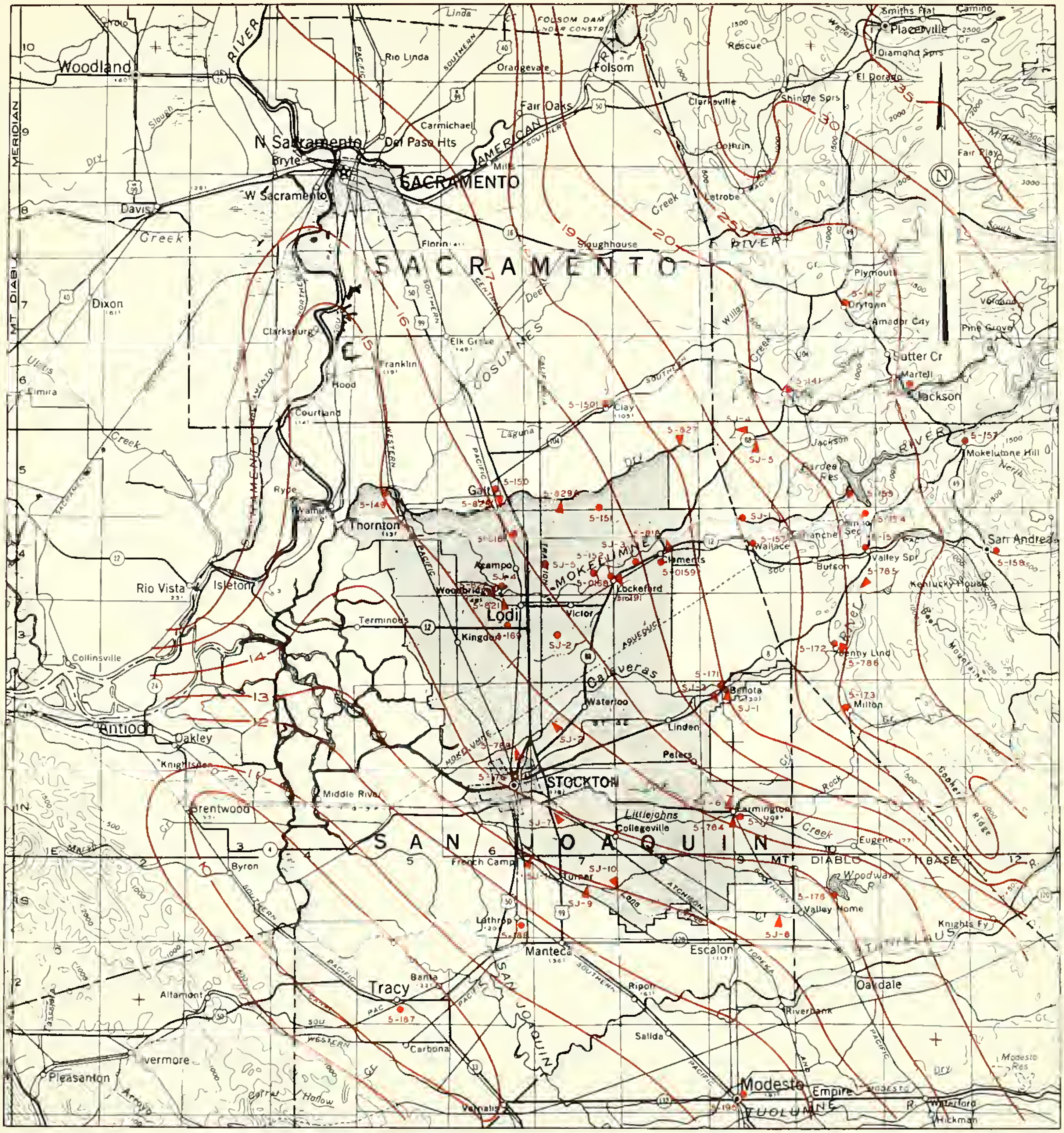
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

HYDROGRAPHIC UNITS AND ORGANIZED WATER AGENCIES 1952

SCALE OF MILES

0 1 2 3



LEGEND

12 —— SEASONAL PRECIPITATION IN INCHES

● PRECIPITATION STATION

▲ STREAM GAGING STATION

▭ INVESTIGATED AREA

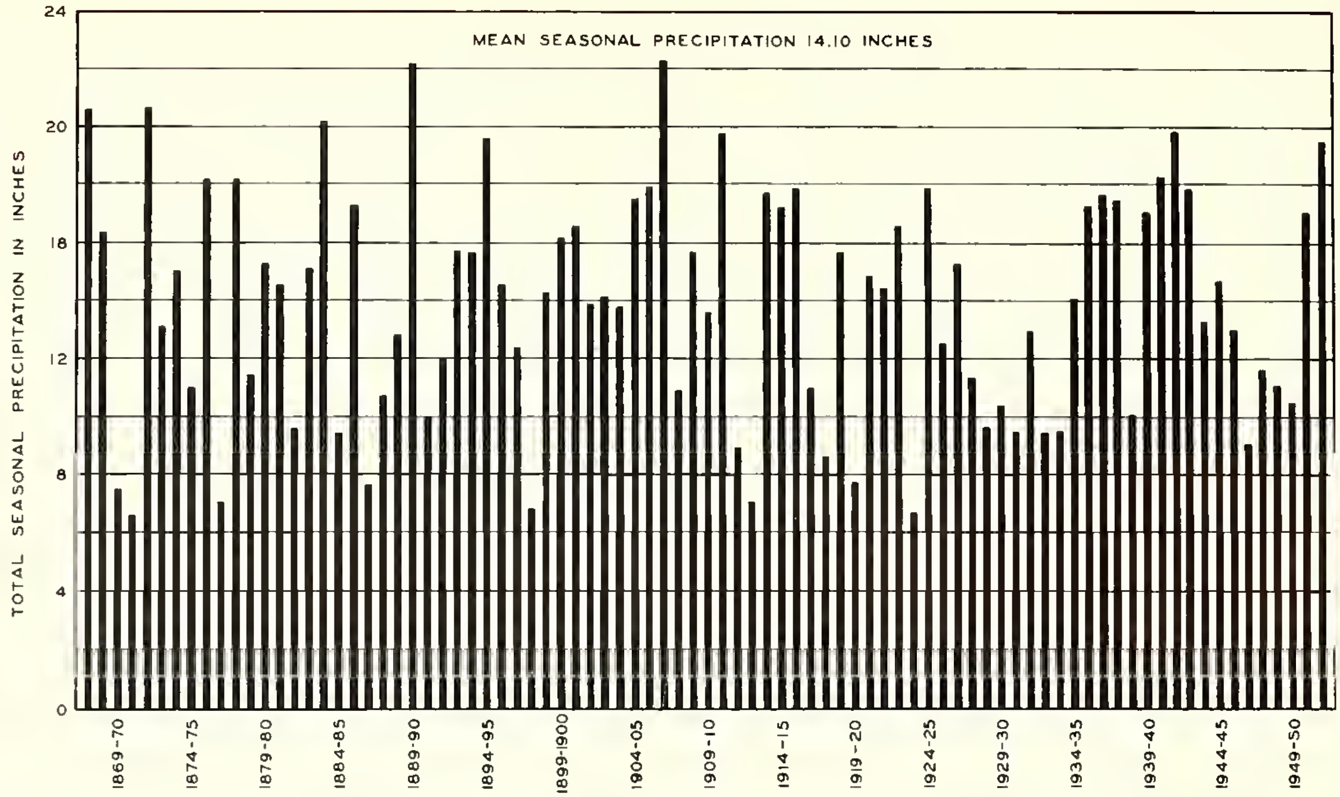
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

LINES OF EQUAL MEAN SEASONAL PRECIPITATION
1898 - 1947

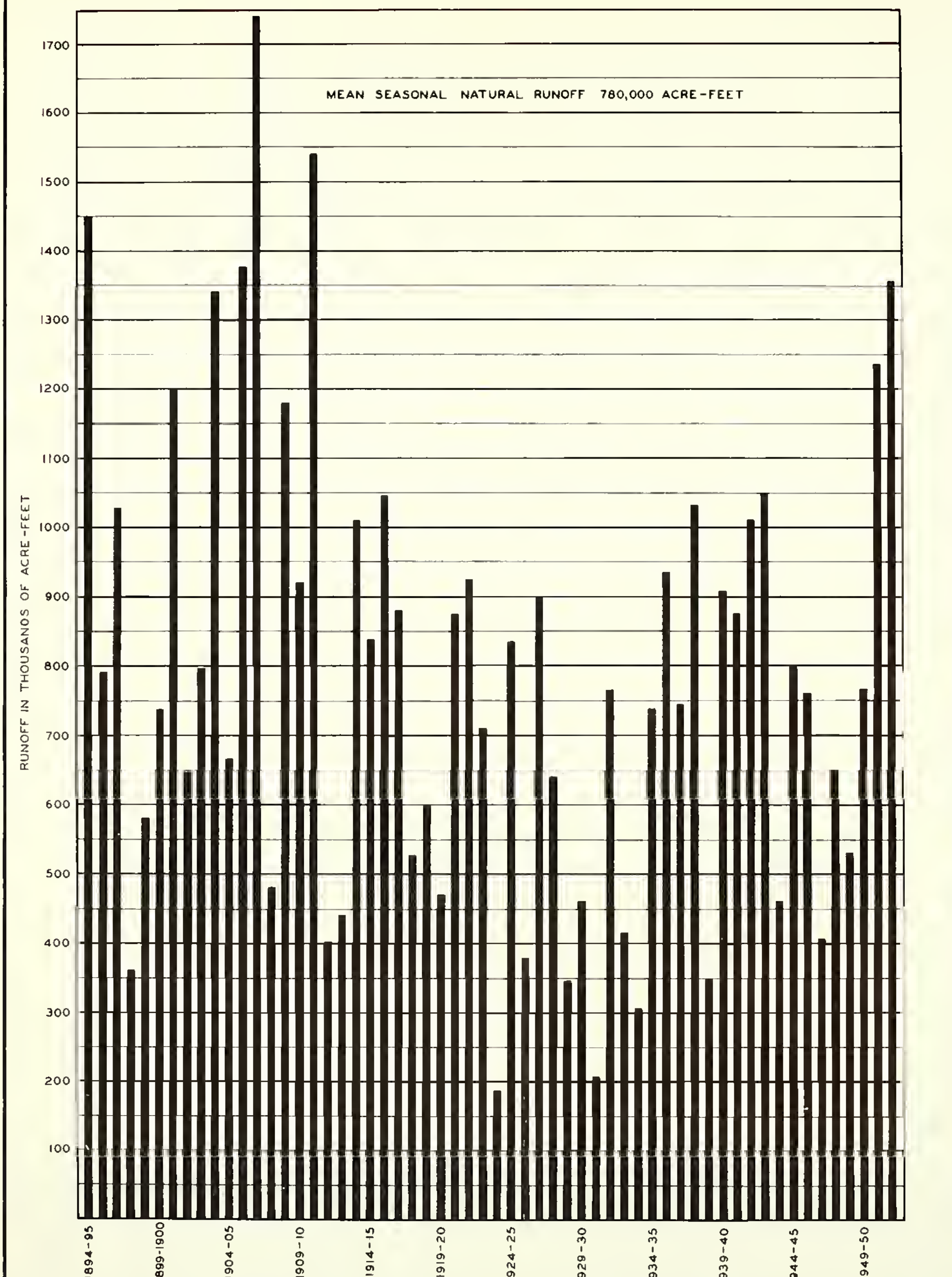
SCALE OF MILES

5 0 5 10 15



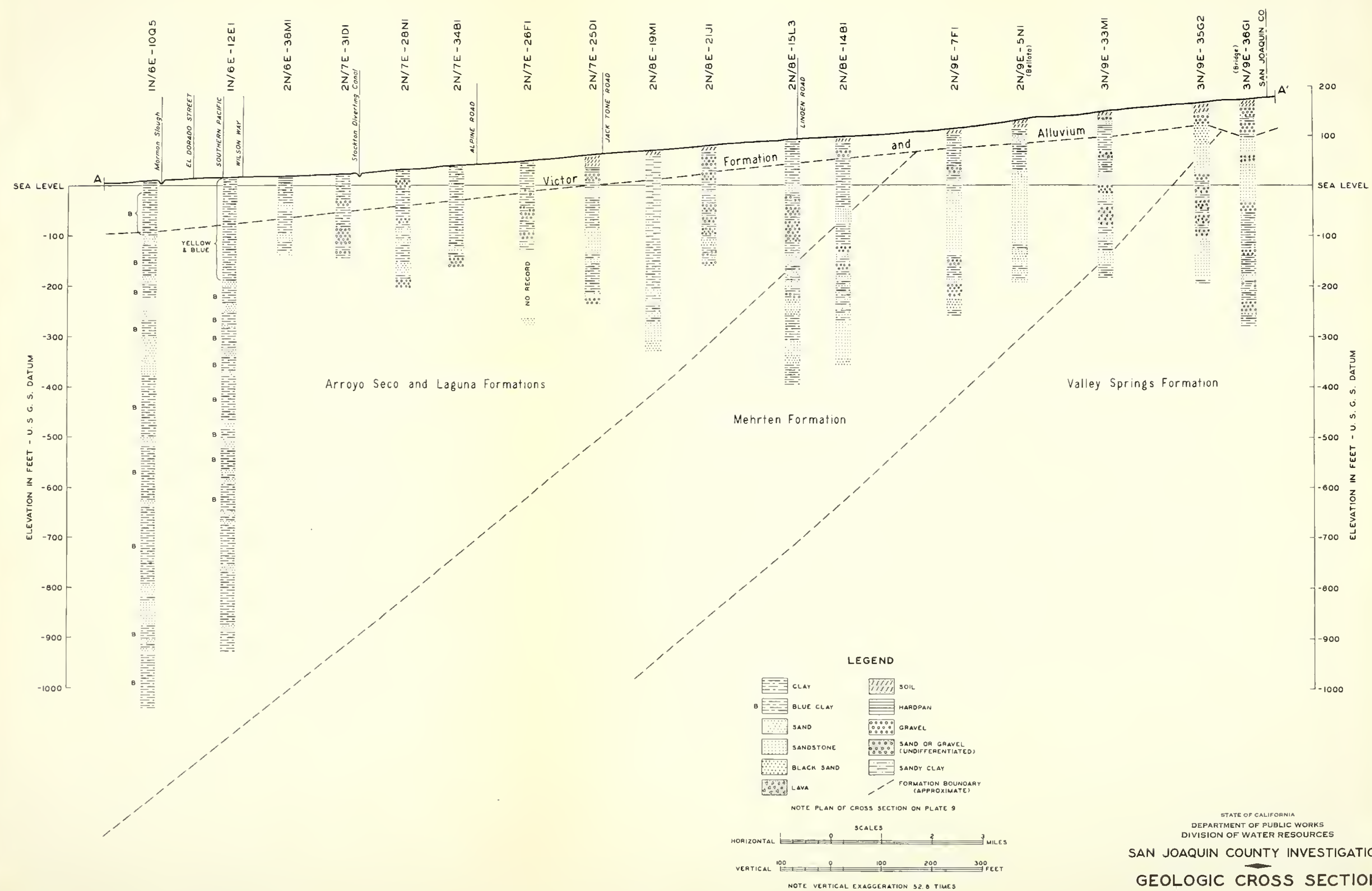
RECORDED SEASONAL PRECIPITATION AT STOCKTON

ACCUMULATED DEPARTURE FROM MEAN SEASONAL PRECIPITATION AT STOCKTON



ESTIMATED SEASONAL NATURAL RUNOFF
OF MOKELUMNE RIVER AT CLEMENTS

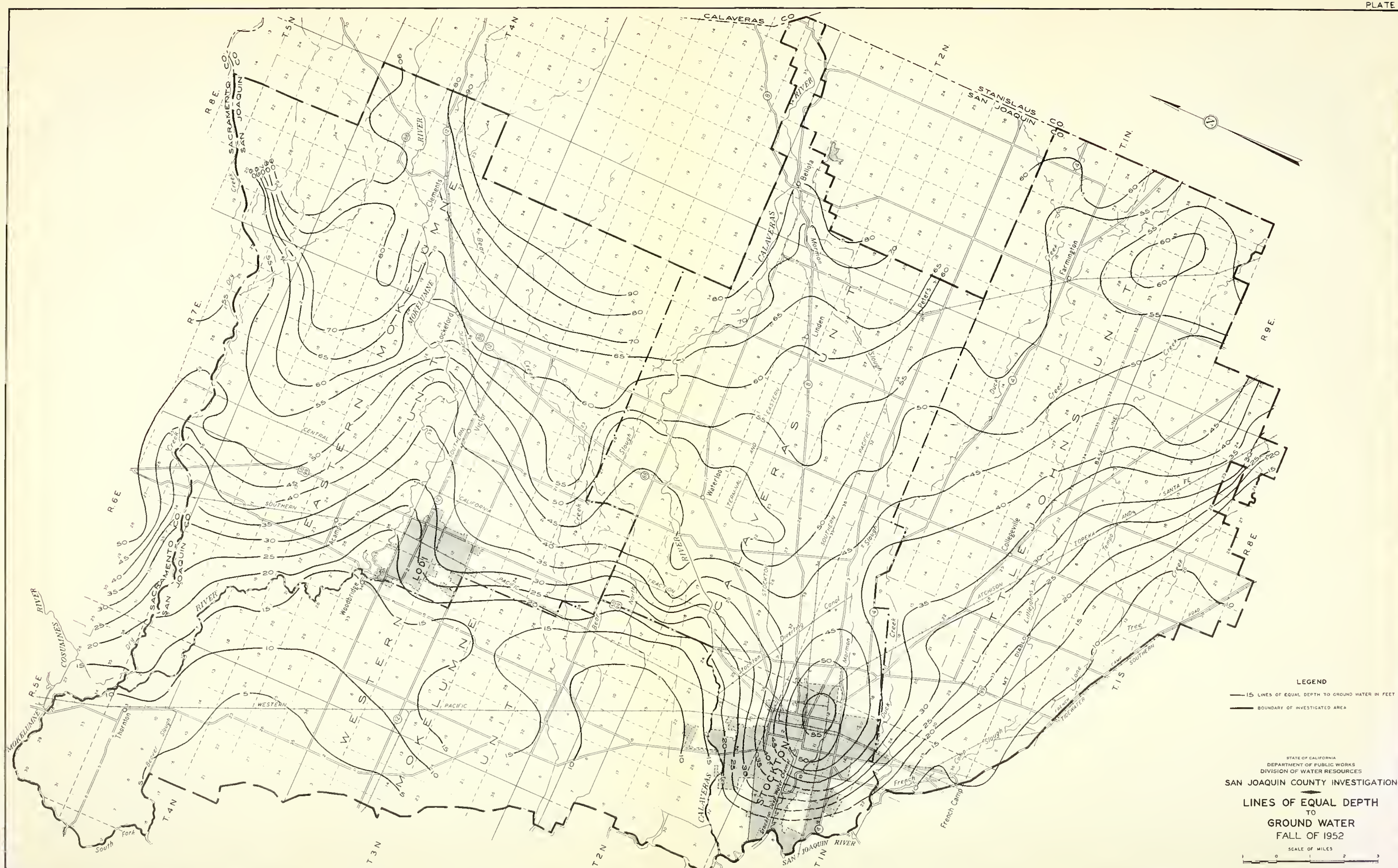
DIVISION OF WATER RESOURCES



STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

GEOLOGIC CROSS SECTION



STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SAN JOAQUIN COUNTY INVESTIGATION

LINES OF EQUAL DEPTH TO GROUND WATER
FALL OF 1952

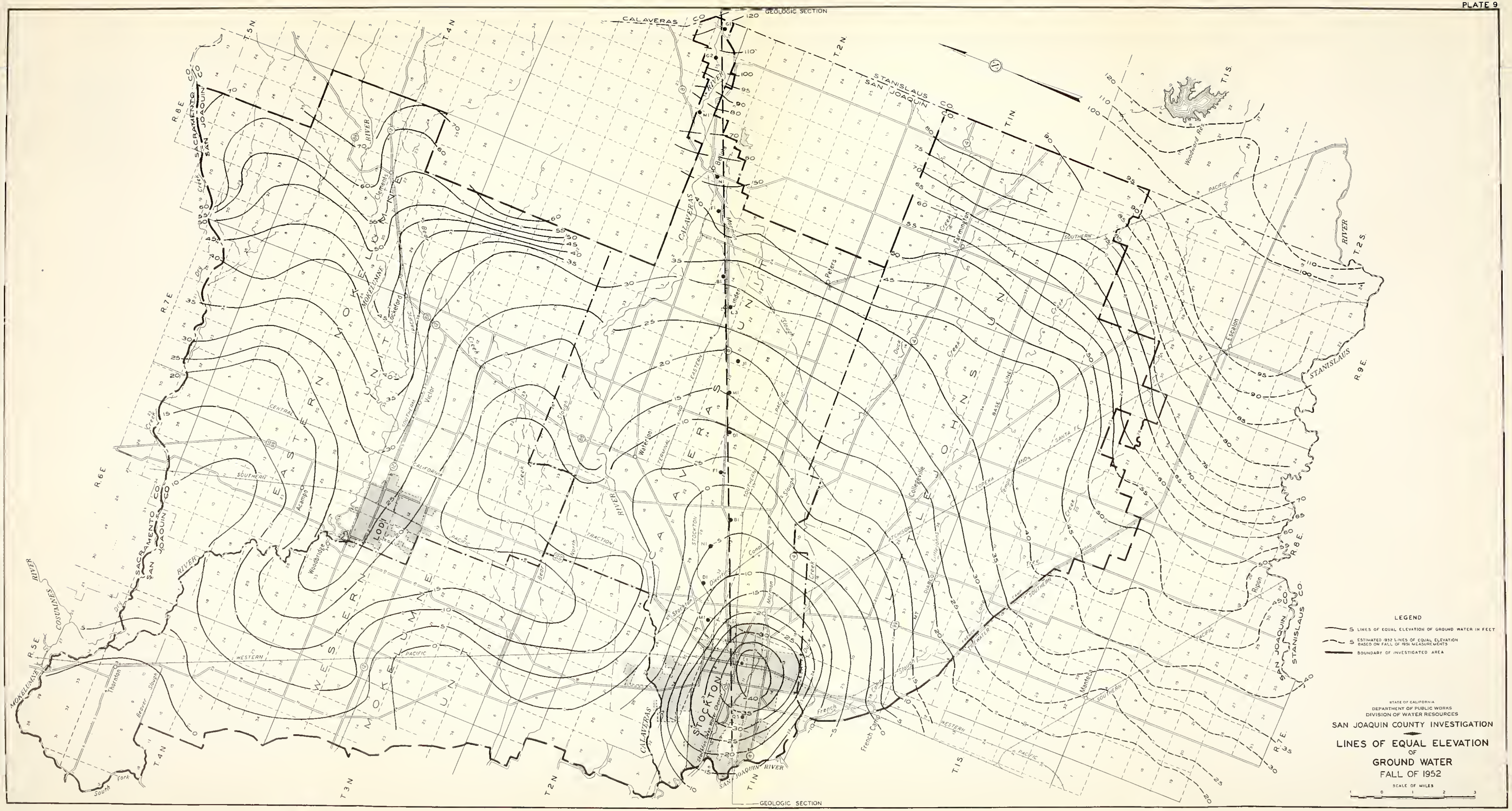
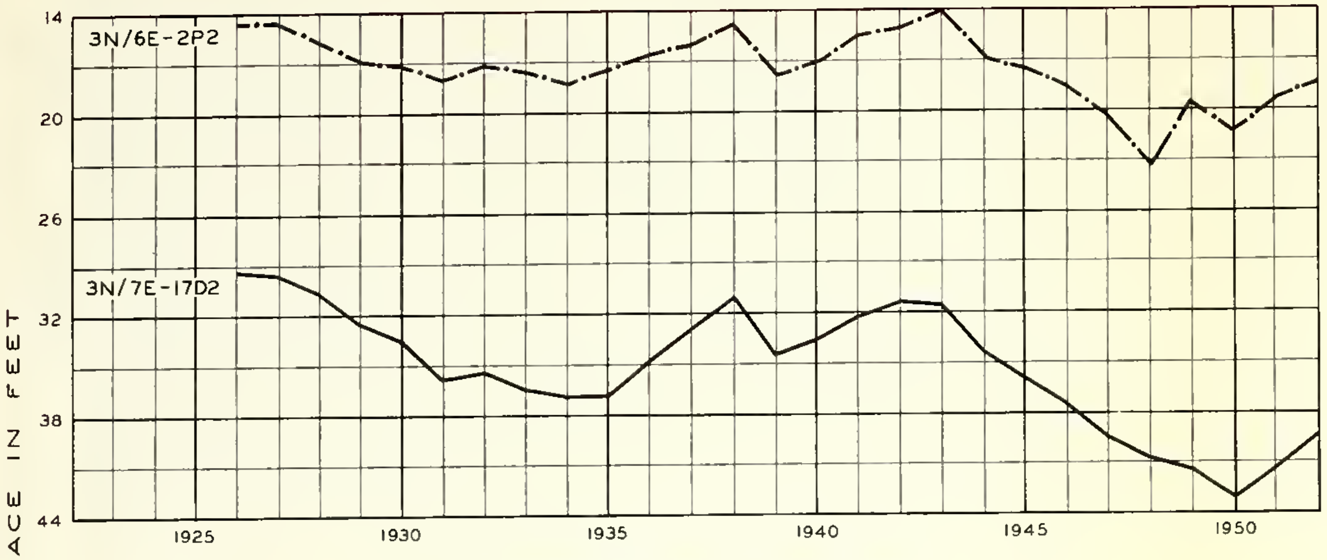
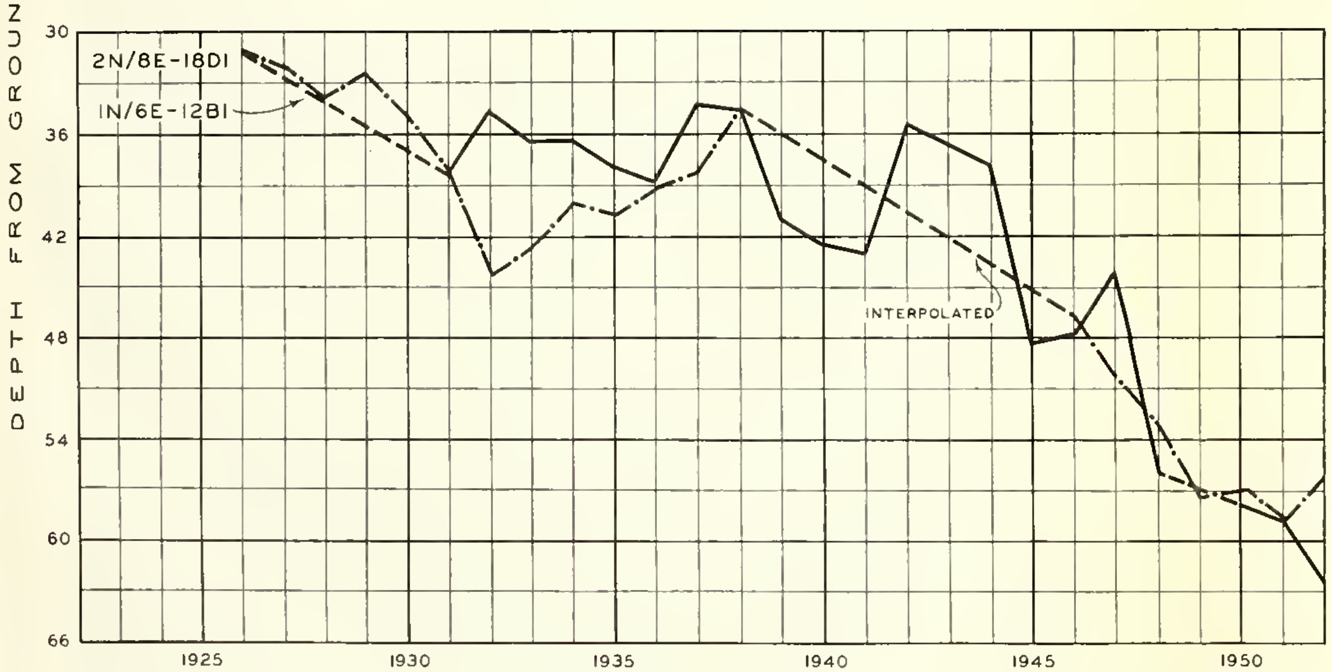

GEOLOGIC SECTION
CALAVERAS CO.
STANISLAUS
SAN JOAQUIN CO.
SACRAMENTO CO.
SAN JOAQUIN
EASTERN MOKELUMNE
WESTERN MOKELUMNE
CALAVERAS
SOUTH SAN JOAQUIN
NORTH SAN JOAQUIN
LODI
STOCKTON
Lockeford
Clements
Victor
Acampo
Woodbridge
Thornton
Waterloo
Linden
Bellota
Farmington
Collegeville
Escalon
Ripon
Manteca
MOKELUMNE RIVER
COSUMNES RIVER
CALAVERAS RIVER
STANISLAUS RIVER
SAN JOAQUIN RIVER
LEGEND
5 LINES OF EQUAL ELEVATION OF GROUND WATER IN FEET
5 ESTIMATED 1952 LINES OF EQUAL ELEVATION BASED ON FALL OF 1951 MEASUREMENTS
BOUNDARY OF INVESTIGATED AREA
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SAN JOAQUIN COUNTY INVESTIGATION
LINES OF EQUAL ELEVATION OF GROUND WATER
FALL OF 1952
SCALE OF MILES
1 0 1 2 3

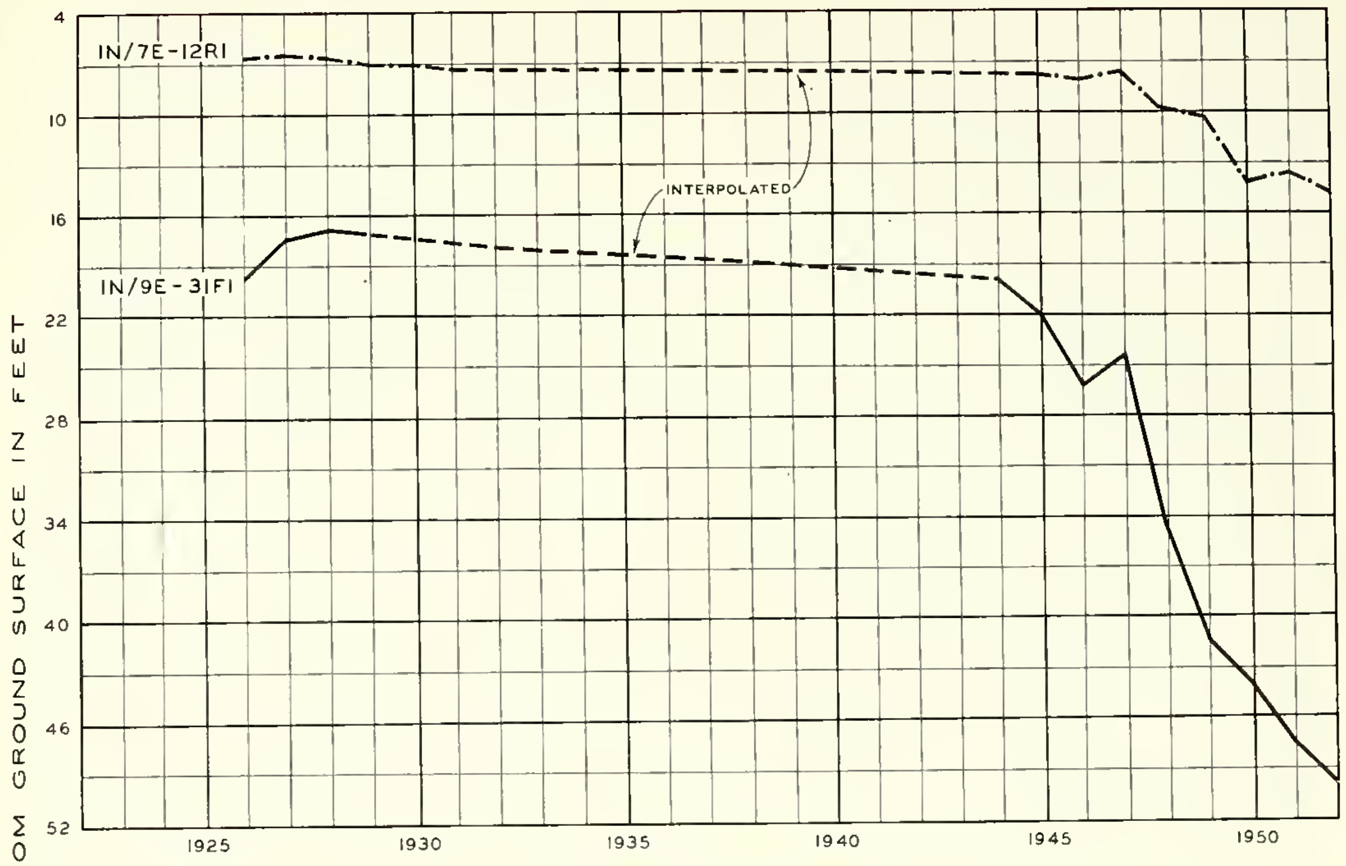
PLATE 10



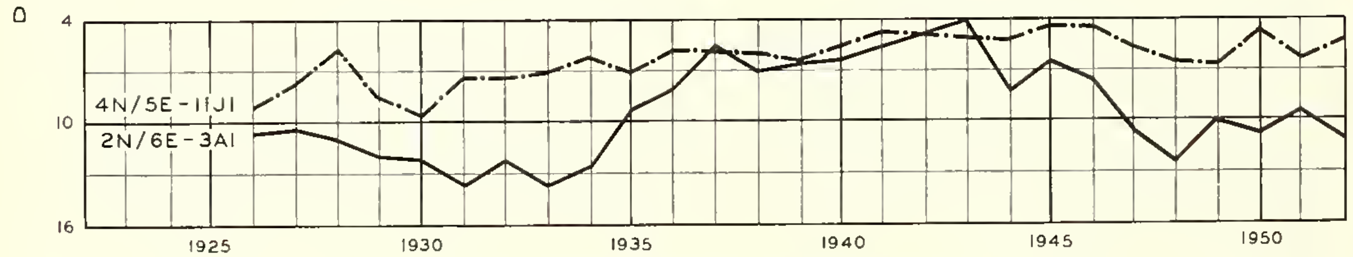
EASTERN MOKELUMNE UNIT



CALAVERAS UNIT



LITTLEJOHNS UNIT

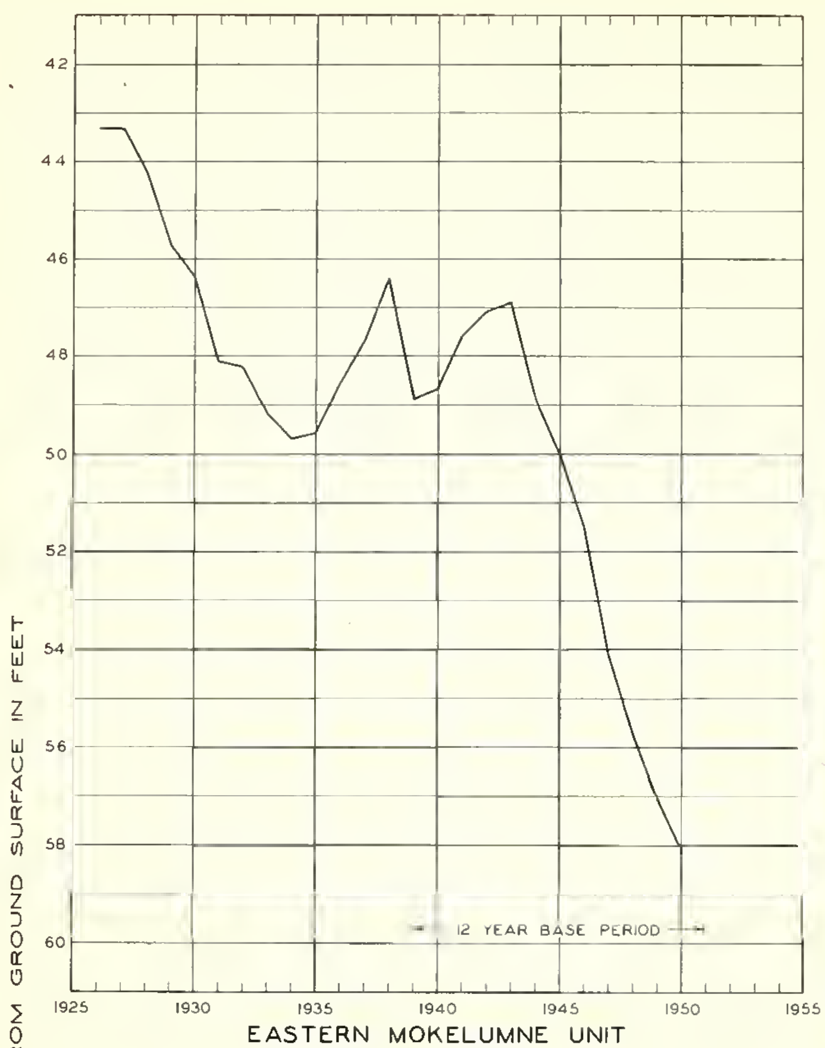


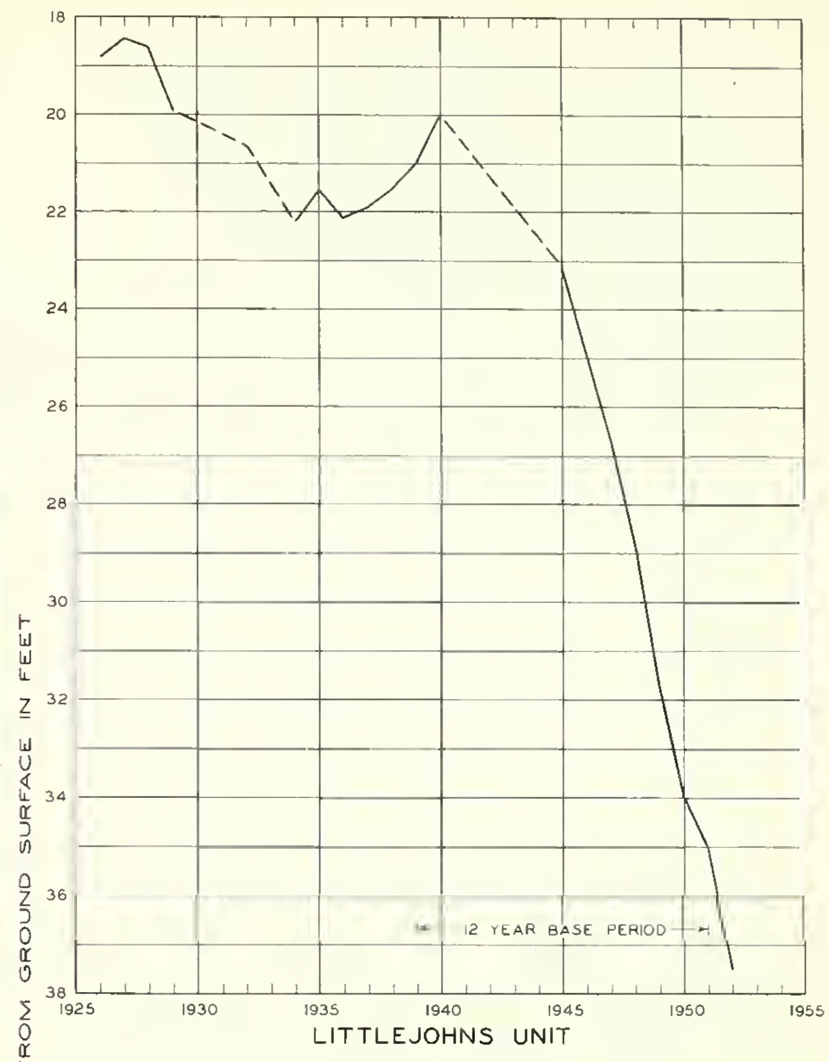
WESTERN MOKELUMNE UNIT

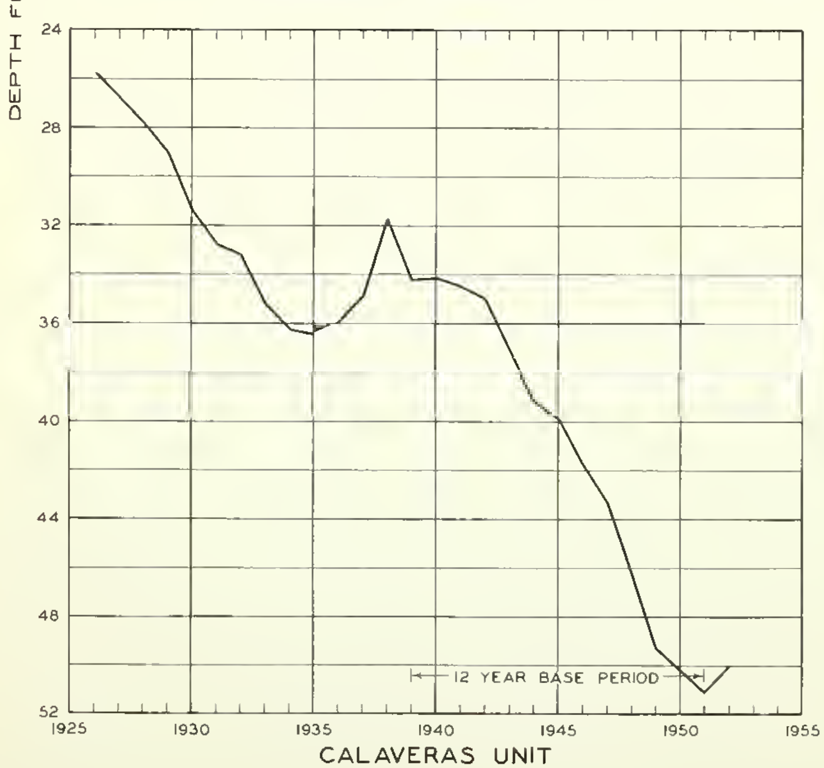
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

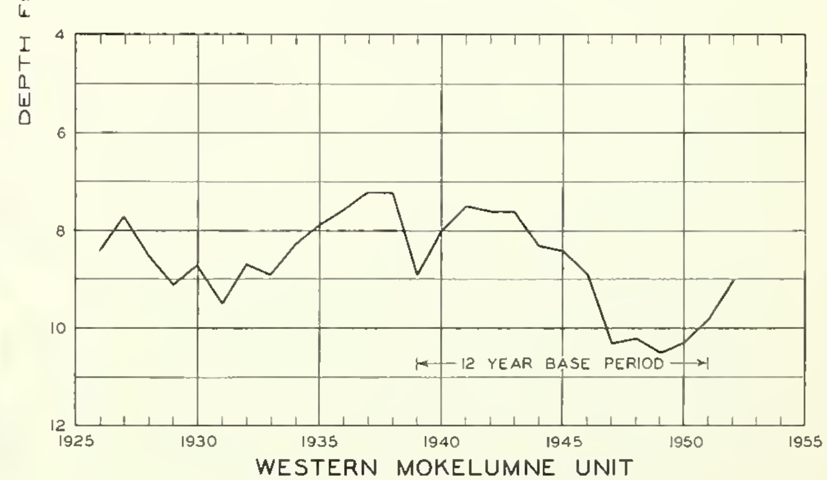
SAN JOAQUIN COUNTY INVESTIGATION

MEASURED FALL DEPTHS TO GROUND WATER AT REPRESENTATIVE WELLS







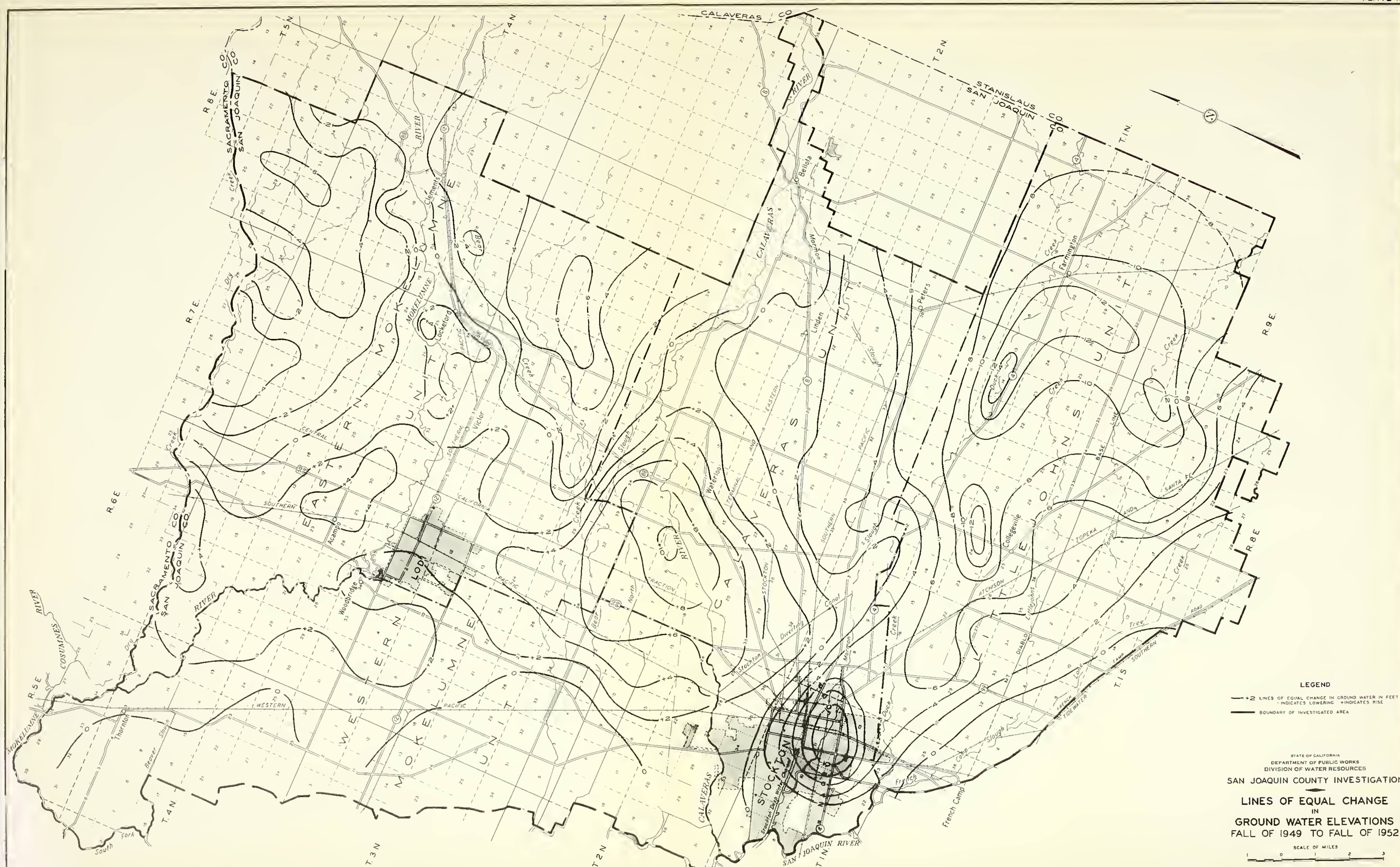


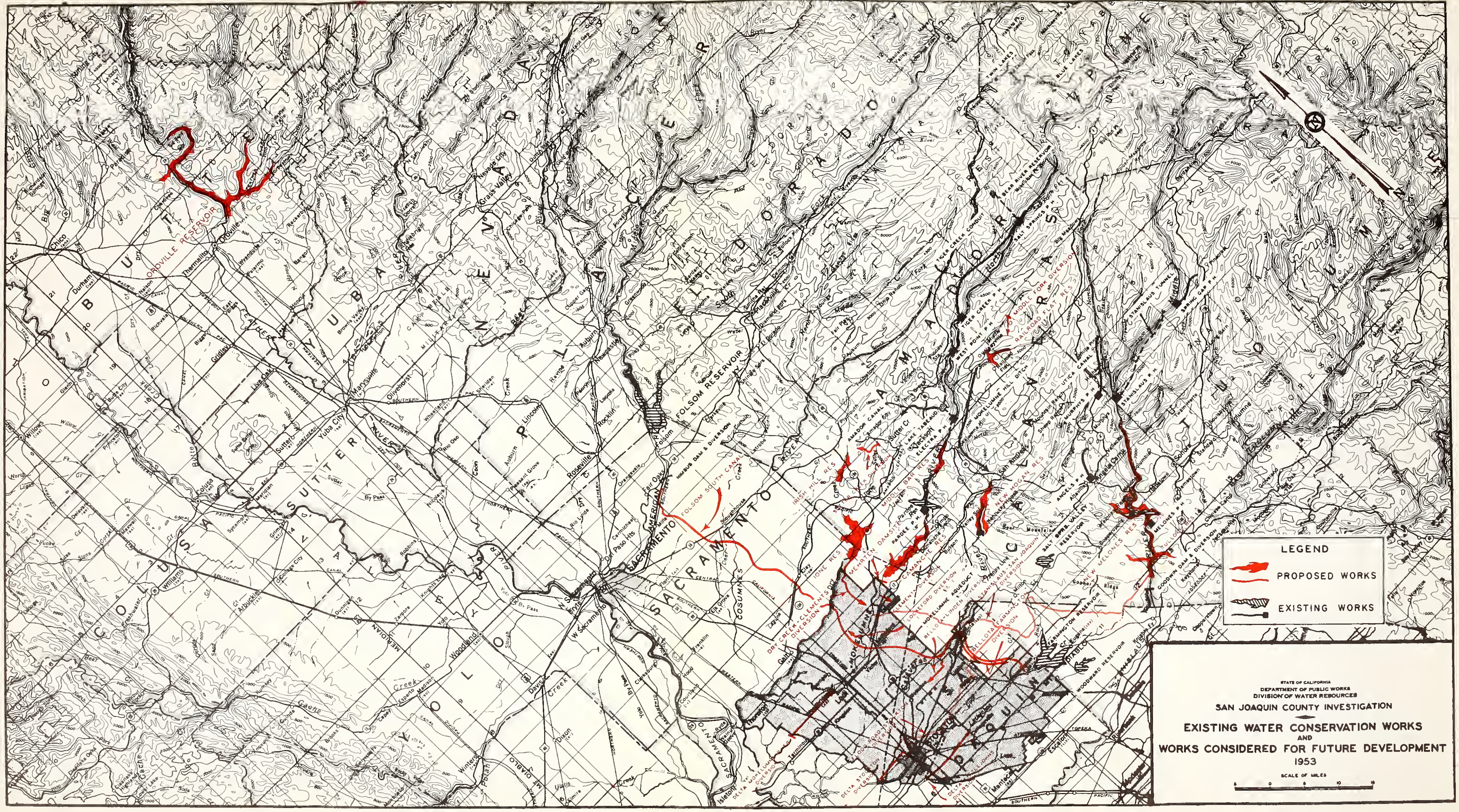
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

ESTIMATED AVERAGE FALL DEPTH TO GROUND WATER


LEGEND
+2 LINES OF EQUAL CHANGE IN GROUND WATER IN FEET
- INDICATES LOWERING + INDICATES RISE
BOUNDARY OF INVESTIGATED AREA
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SAN JOAQUIN COUNTY INVESTIGATION
LINES OF EQUAL CHANGE
IN
GROUND WATER ELEVATIONS
FALL OF 1939 TO FALL OF 1951
SCALE OF MILES
1 0 1 2 3
CALAVERAS CO
STANISLAUS CO
SAN JOAQUIN CO
SACRAMENTO CO
EASTERN MOKELUMNE UNIT
WESTERN MOKELUMNE UNIT
CALAVERAS UNIT
LITTLEJOHNS UNIT
LODI
STOCKTON
Lockeford
Clements
Bellota
Linden
Farmington
Waterloo
Collegeville
Acampo
Woodbridge
Thornton
French Camp
MOKELUMNE RIVER
CALAVERAS RIVER
SAN JOAQUIN RIVER
COSUMNES RIVER
T5N
T4N
T3N
T2N
T1N
T1S
R5E
R6E
R7E
R8E
R9E


CALAVERAS CO
STANISLAUS CO
SAN JOAQUIN CO
SACRAMENTO CO
SAN JOAQUIN CO
EASTERN MOKELUMNE UNIT
WESTERN MOKELUMNE UNIT
CALAVERAS UNIT
LITTLEJOHNS UNIT
STOCKTON
LODI
Lockeford
Clements
Victor
Acampo
Woodbridge
Thornton
Bellota
Linden
Peters
Farmington
Collegeville
French Camp
MOKELUMNE RIVER
CALAVERAS RIVER
SAN JOAQUIN RIVER
COSUMNES RIVER
LEGEND
+2 LINES OF EQUAL CHANGE IN GROUND WATER IN FEET
- INDICATES LOWERING + INDICATES RISE
BOUNDARY OF INVESTIGATED AREA
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SAN JOAQUIN COUNTY INVESTIGATION
LINES OF EQUAL CHANGE
IN
GROUND WATER ELEVATIONS
FALL OF 1949 TO FALL OF 1952
SCALE OF MILES
1 0 1 2 3


LEGEND
PROPOSED WORKS
EXISTING WORKS
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SAN JOAQUIN COUNTY INVESTIGATION
EXISTING WATER CONSERVATION WORKS
AND
WORKS CONSIDERED FOR FUTURE DEVELOPMENT
1953
SCALE OF MILES
5 0 5 10 15
OROVILLE RESERVOIR
FOLSOM RESERVOIR
FOLSOM SOUTH CANAL
BUTTE
YUBA
SUTTER
COLUSA
YOLO
NEVADA
PLACER
EL DORADO
AMADOR
CALAVERAS
SACRAMENTO
SAN JOAQUIN
TUOLUMNE
Sacramento
Marysville
Yuba City
Chico
Oroville
Auburn
Roseville
Woodland
Stockton

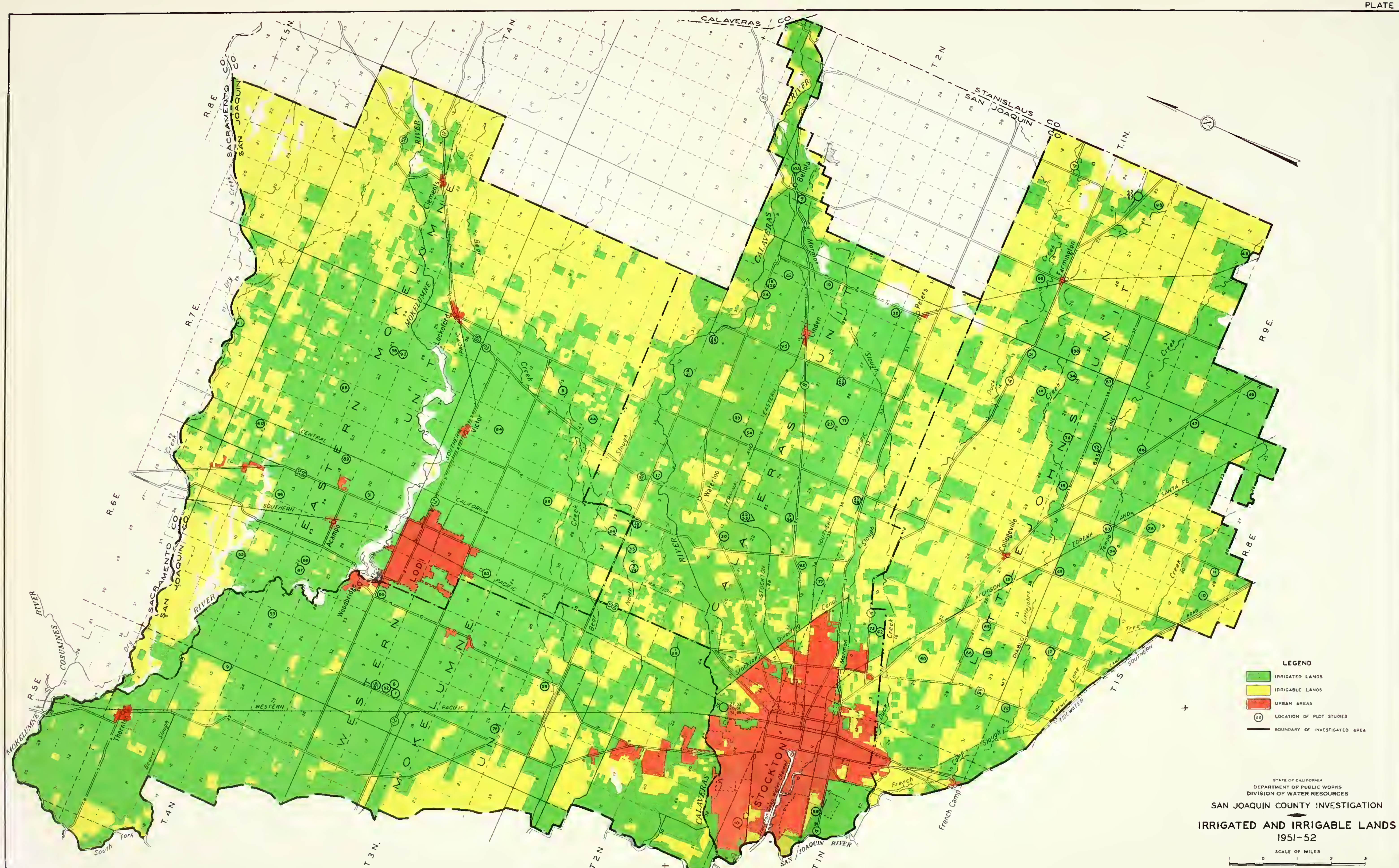
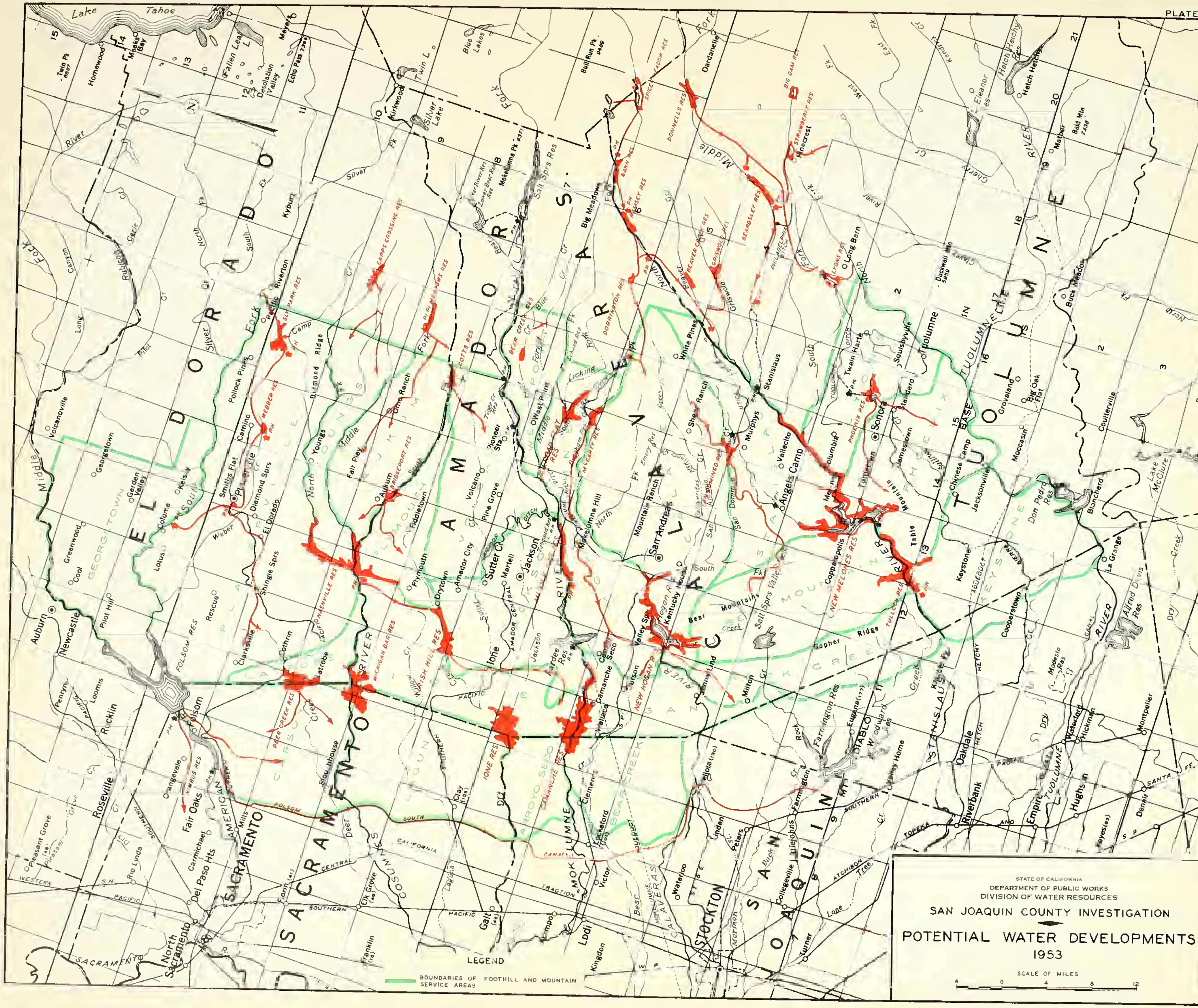
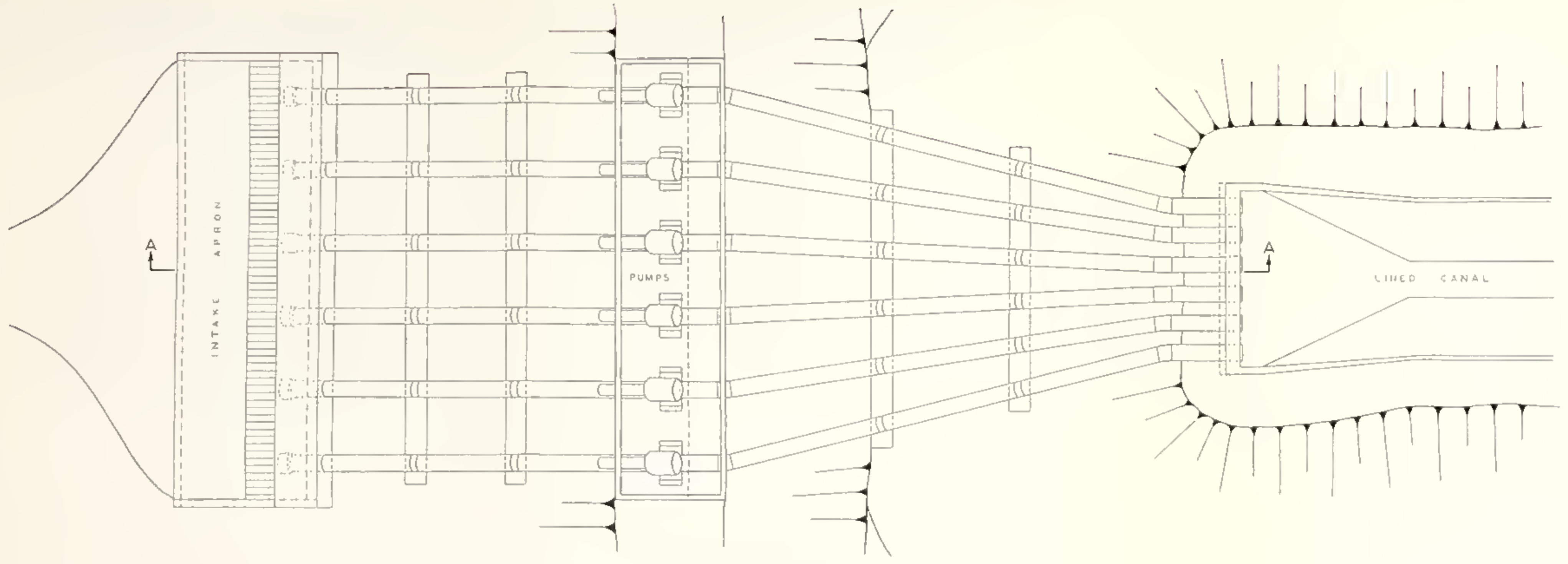

LEGEND
IRRIGATED LANDS
IRRIGABLE LANDS
URBAN AREAS
LOCATION OF PLOT STUDIES
BOUNDARY OF INVESTIGATED AREA
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SAN JOAQUIN COUNTY INVESTIGATION
IRRIGATED AND IRRIGABLE LANDS
1951-52
SCALE OF MILES
EASTERN MOKELUMNE UNIT
WESTERN MOKELUMNE UNIT
CALAVERAS UNIT
LITTLE JOHNS UNIT
STOCKTON
LODI
Woodbridge
Acampo
Victor
Lockeford
Clements
Bellota
Linden
Peters
Farmington
Collegeville
Thornton
CALAVERAS CO
STANISLAUS CO
SAN JOAQUIN CO
SACRAMENTO CO
MOKELUMNE RIVER
CALAVERAS RIVER
SAN JOAQUIN RIVER
COSUMNES RIVER

PLATE 16

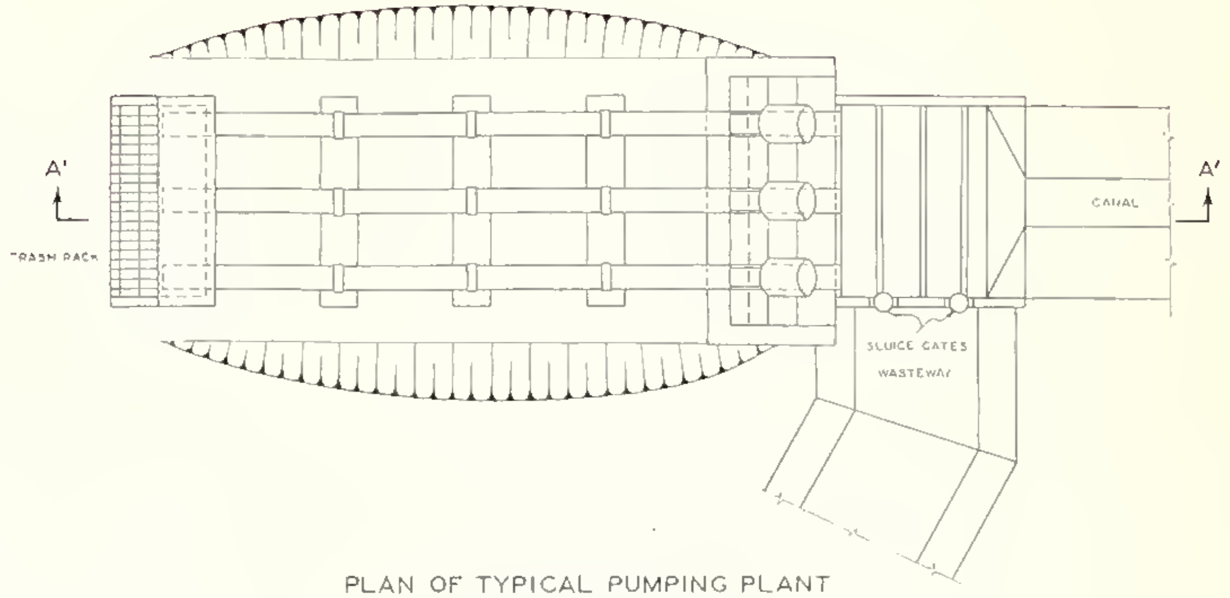

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SAN JOAQUIN COUNTY INVESTIGATION
POTENTIAL WATER DEVELOPMENTS
1953
SCALE OF MILES
4 0 4 8 12
LEGEND
BOUNDARIES OF FOOTHILL AND MOUNTAIN SERVICE AREAS



PLAN OF DELTA PUMPING PLANT

SCALE OF FEET

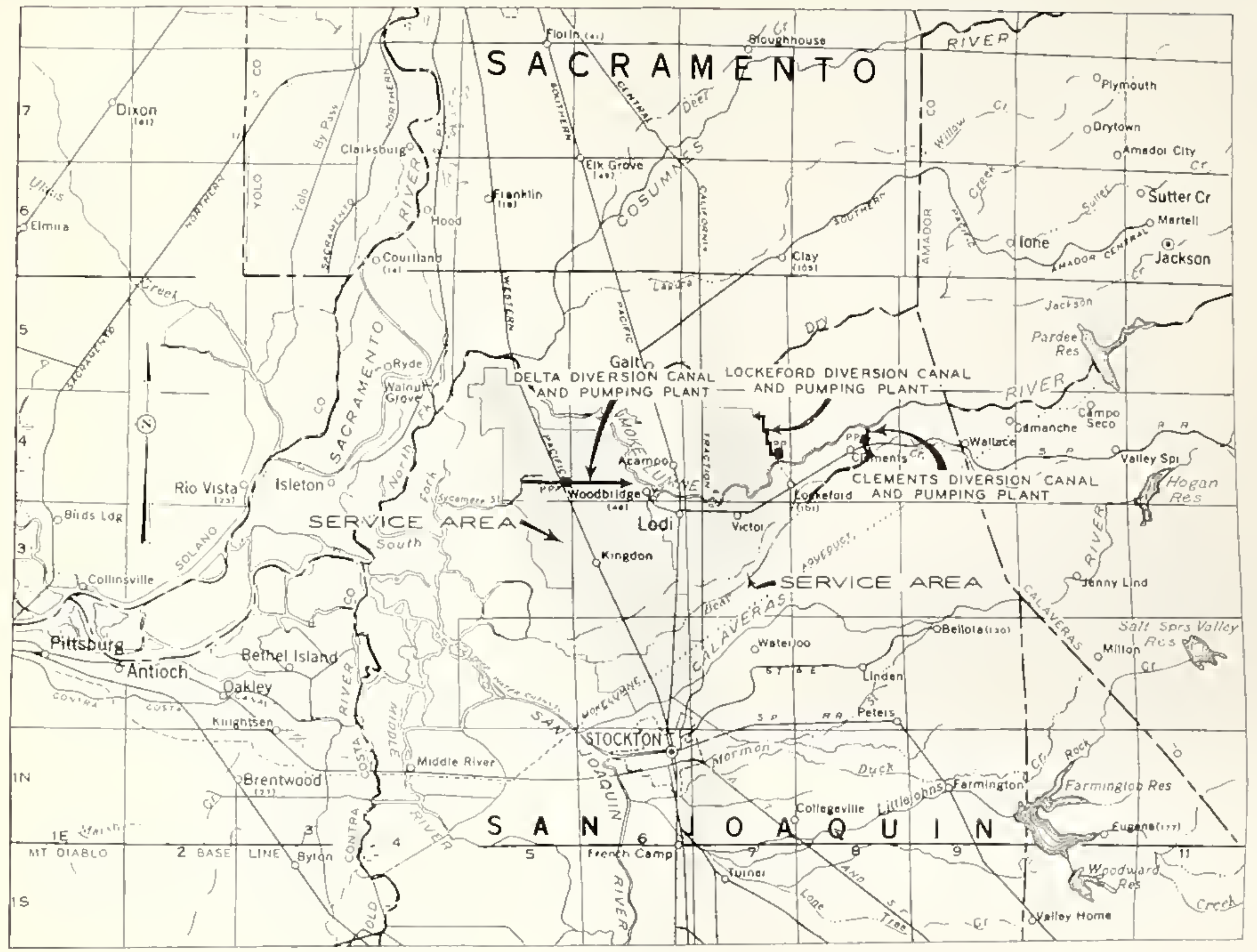
10 0 10 20



PLAN OF TYPICAL PUMPING PLANT

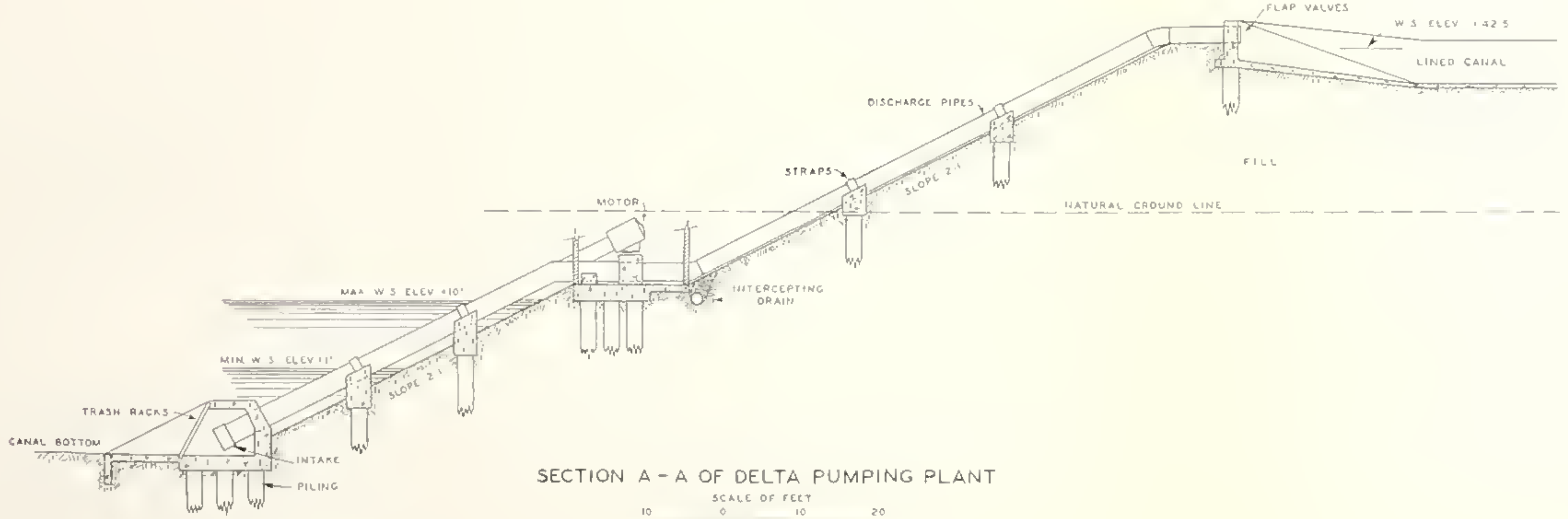
SCALE OF FEET

10 0 10 20



PROJECT AREA

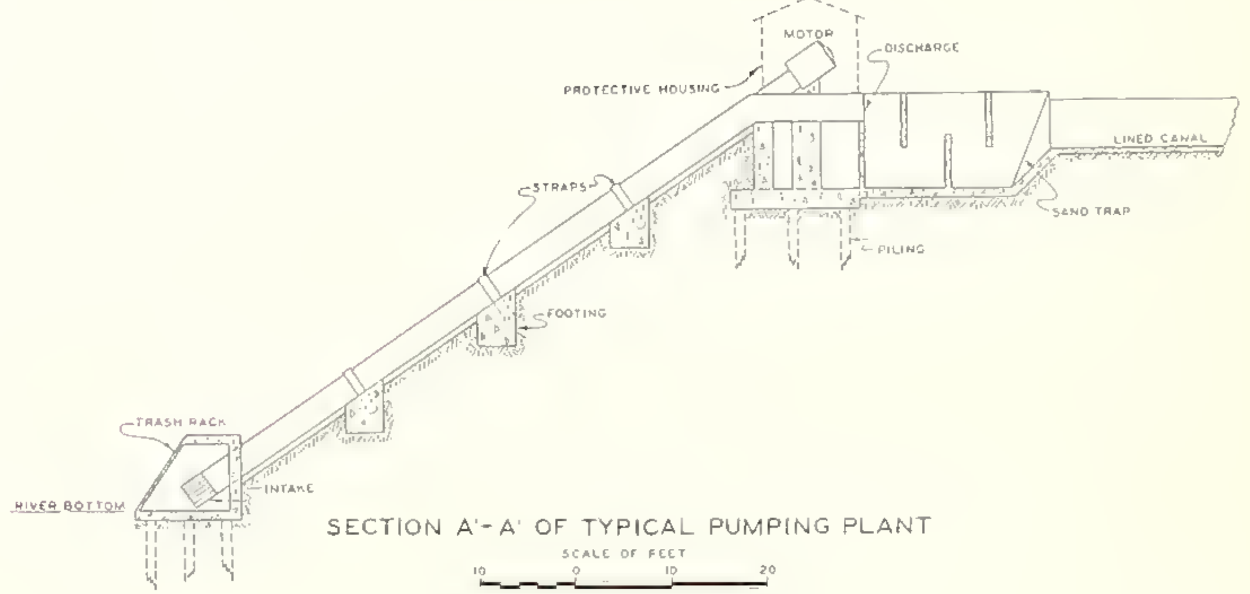
SCALE OF MILES



SECTION A-A OF DELTA PUMPING PLANT

SCALE OF FEET

10 0 10 20



SECTION A'-A' OF TYPICAL PUMPING PLANT

SCALE OF FEET

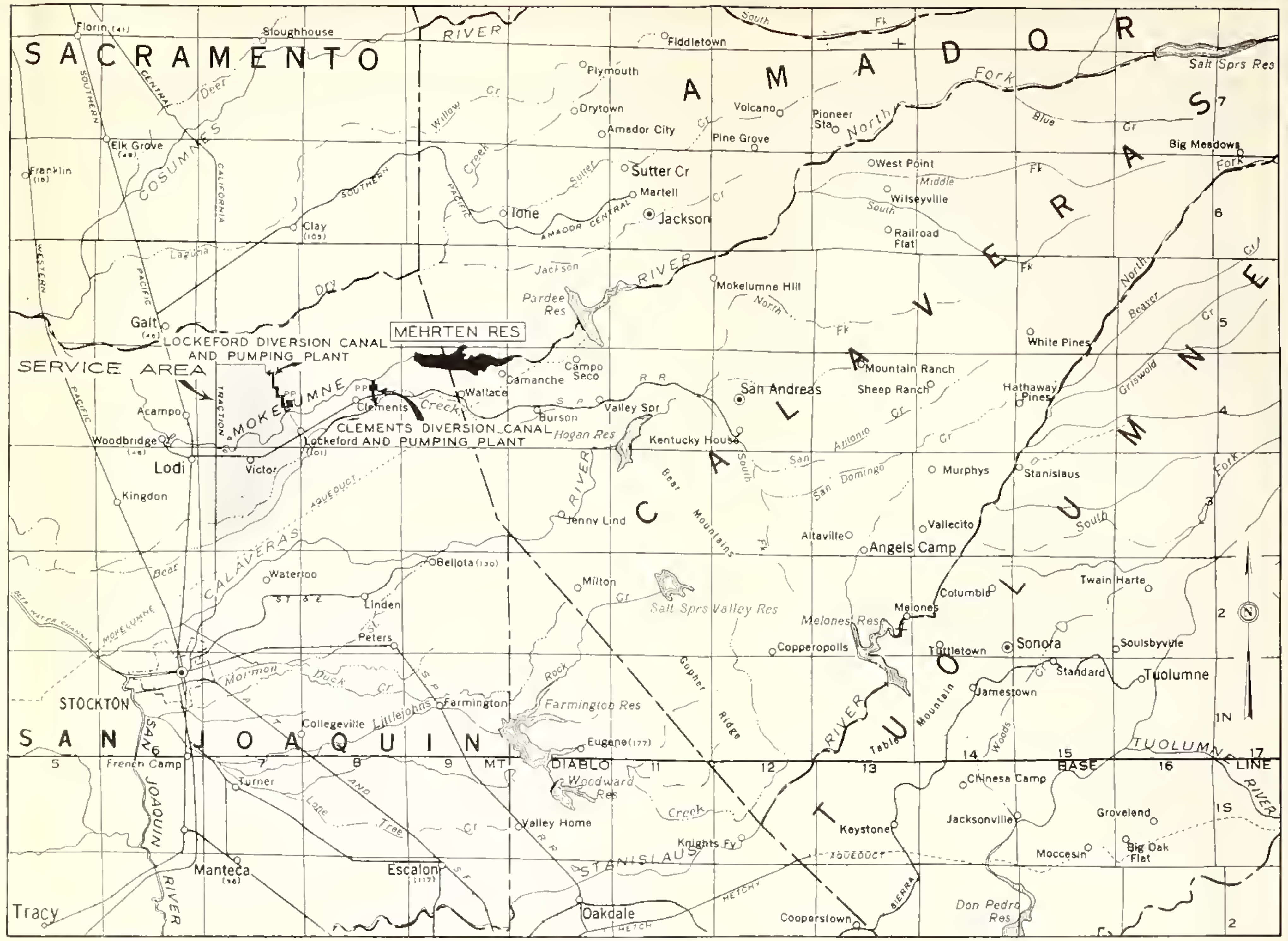
10 0 10 20

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

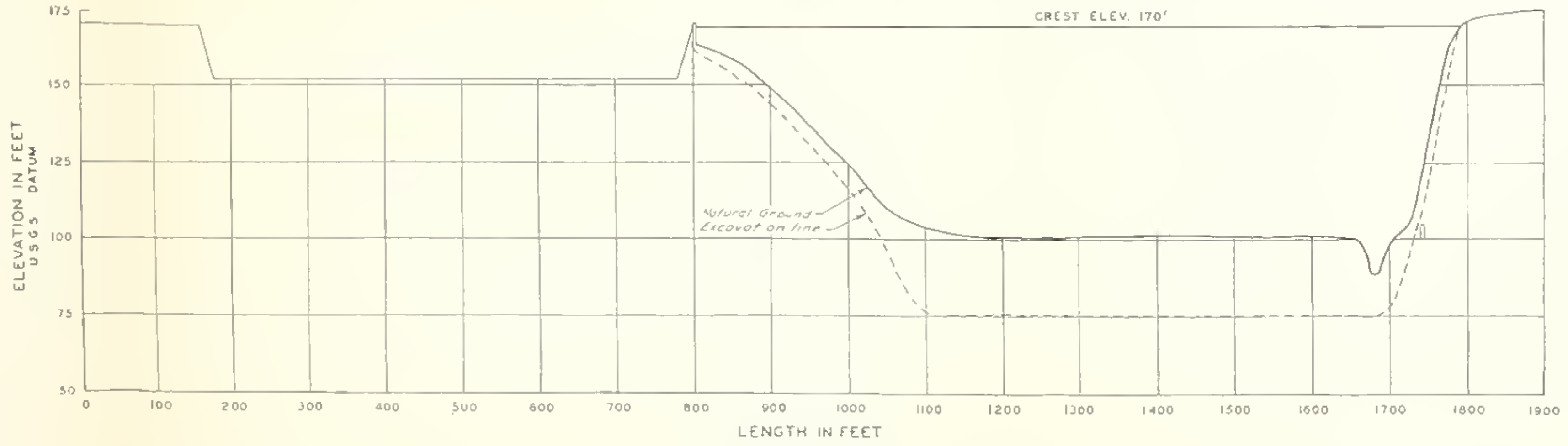
SAN JOAQUIN COUNTY INVESTIGATION

DELTA - MOKELUMNE RIVER
DIVERSION PROJECT
1953

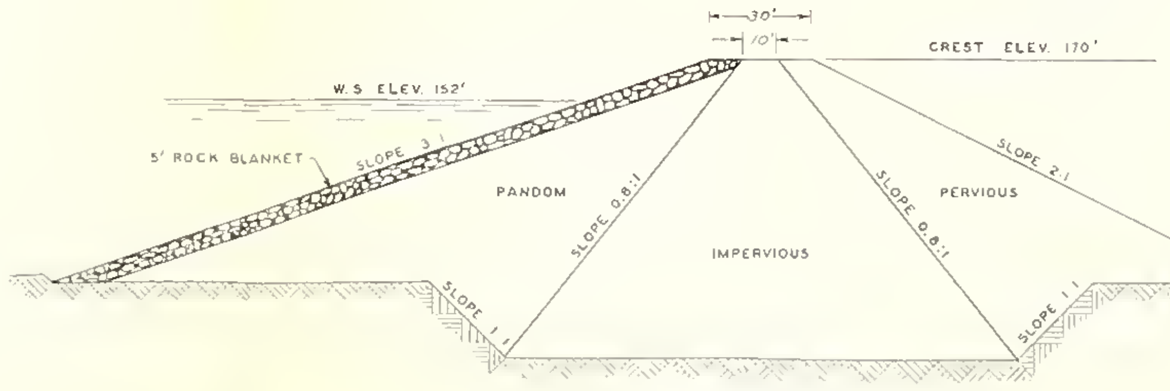
GENERAL PLAN
SCALE OF FEET
0 100 200



PROJECT AREA
SCALE OF MILES
4 0 4 8



PROFILE OF DAM
LOOKING UPSTREAM

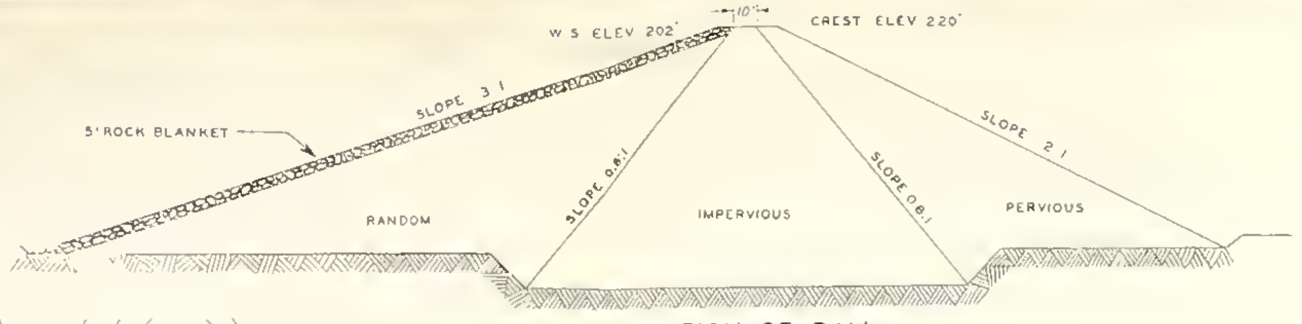


SECTION OF DAM
SCALE OF FEET
0 25 50

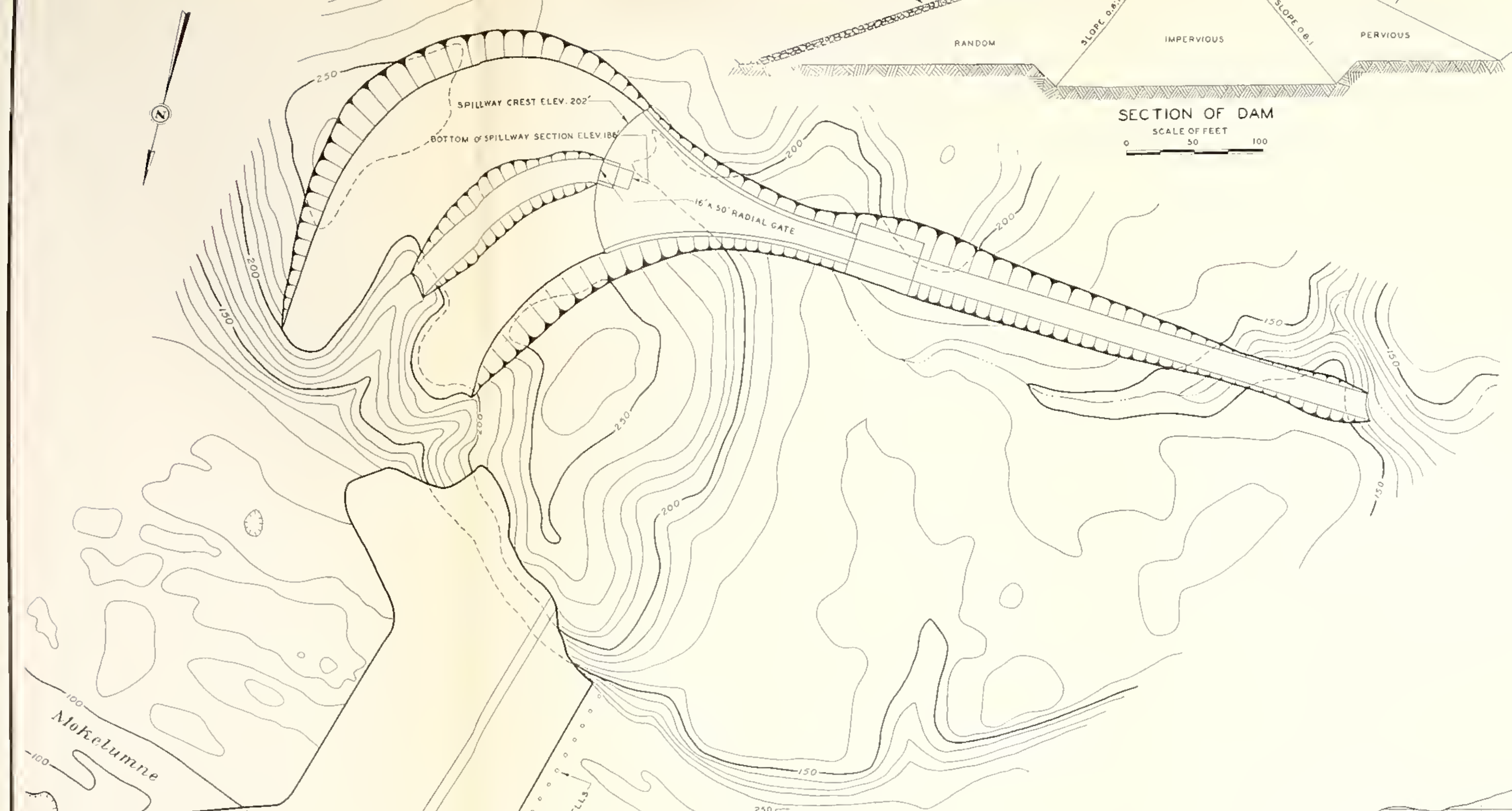
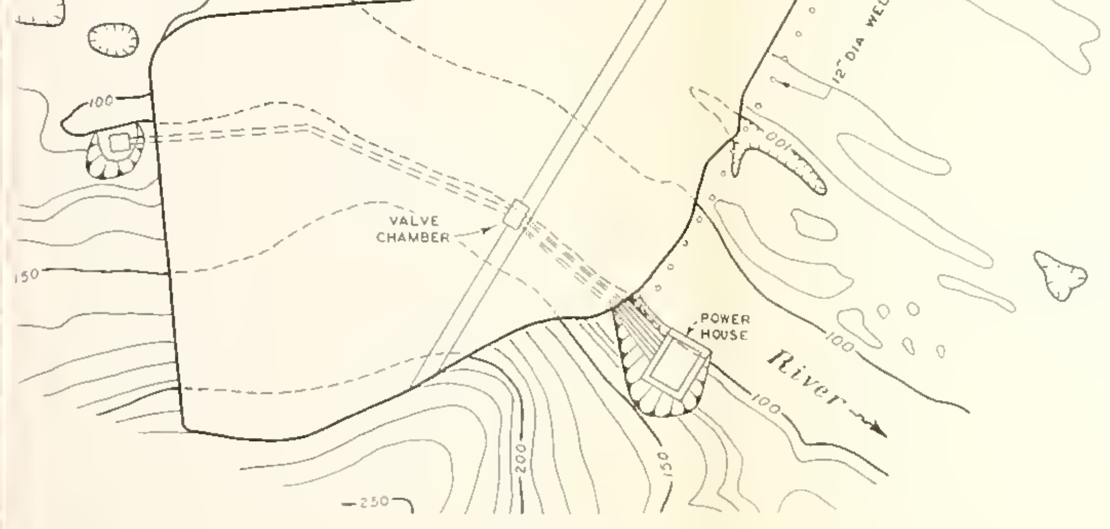
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

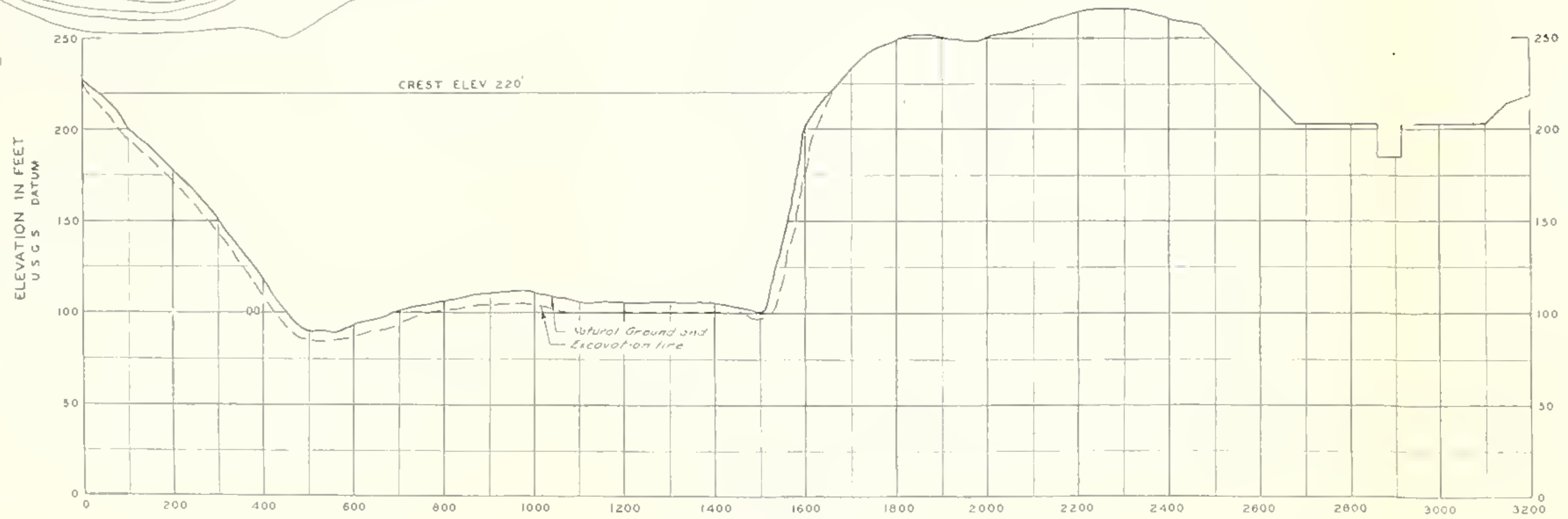
MEHRTEN PROJECT
1953



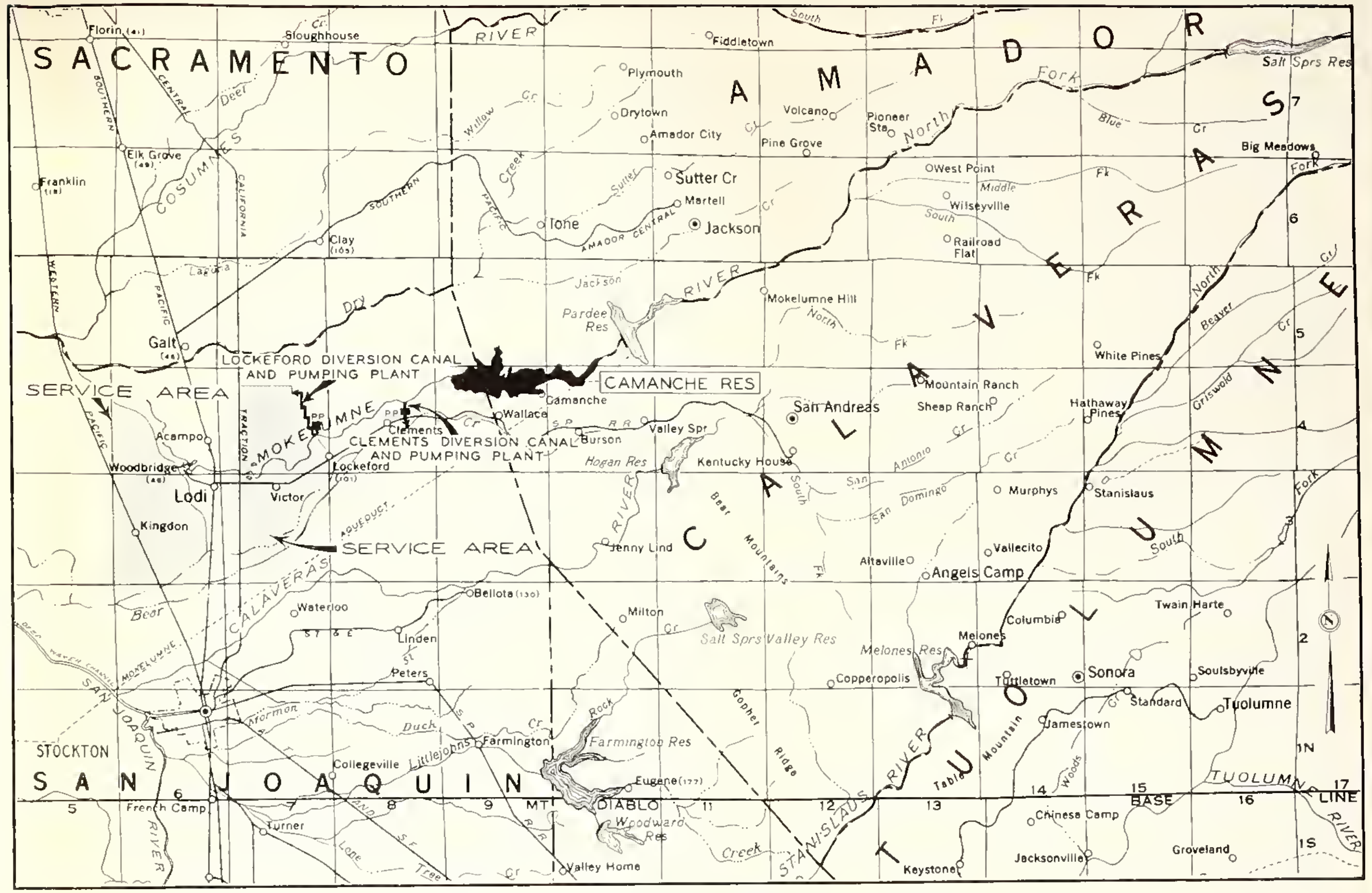
SECTION OF DAM
SCALE OF FEET
0 50 100

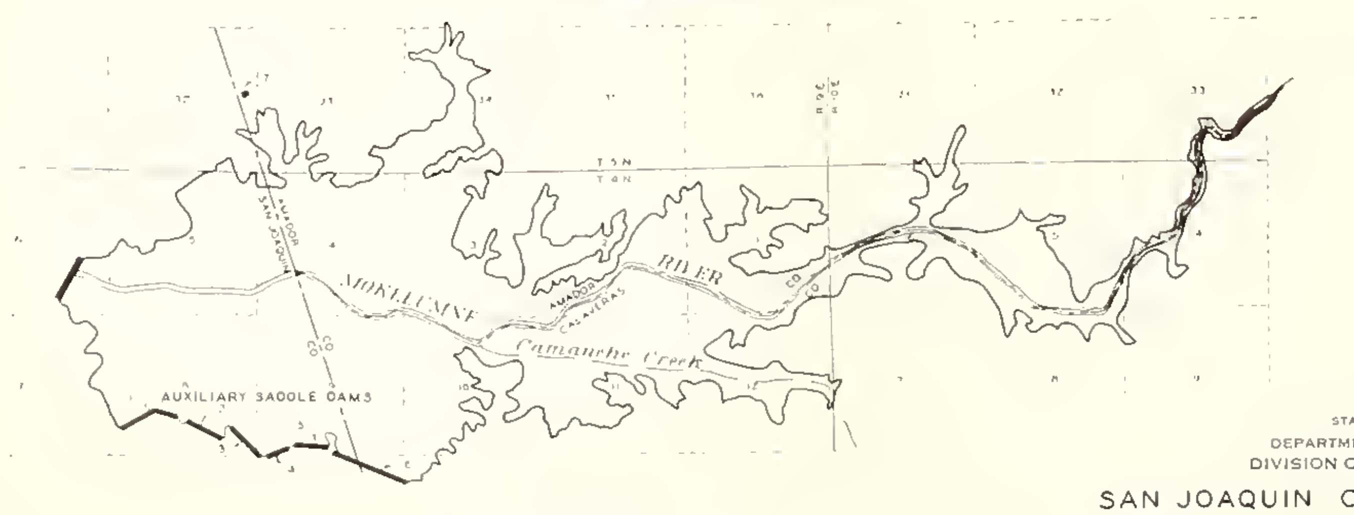
GENERAL PLAN
SCALE OF FEET
0 200 400



LENGTH IN FEET
PROFILE OF DAM
LOOKING UPSTREAM

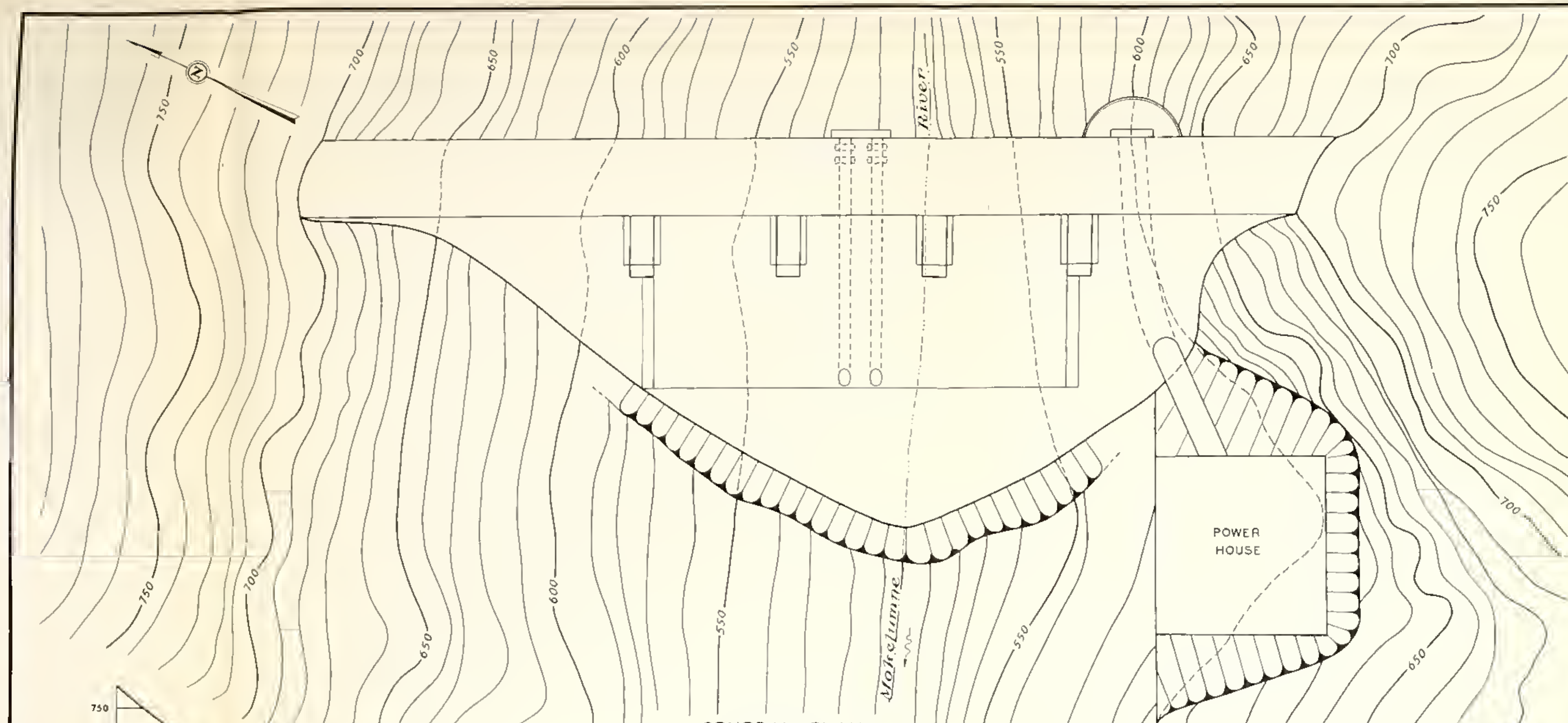


PROJECT AREA
SCALE OF MILES
4 0 4 8

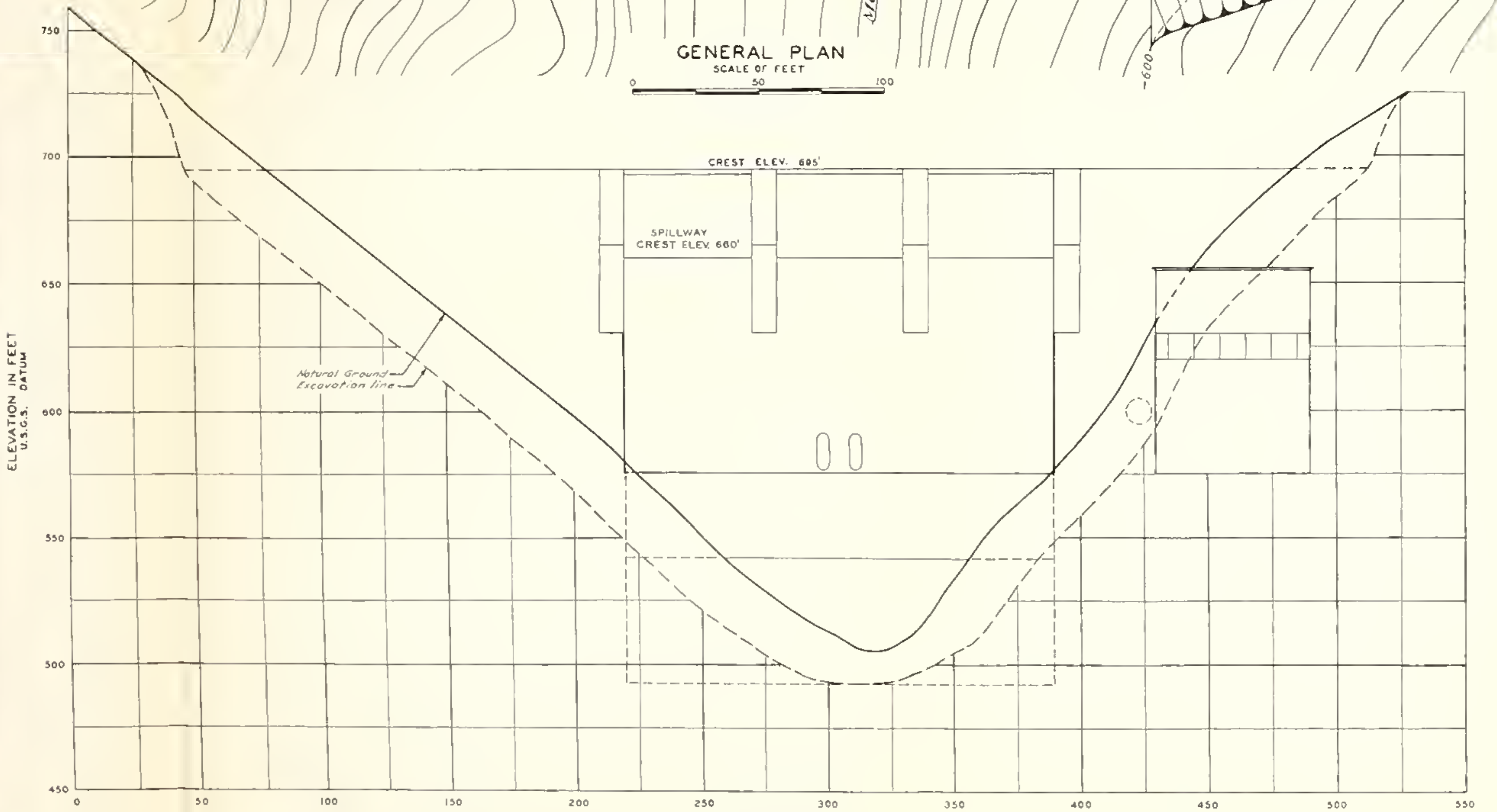


RESERVOIR SITE
SCALE OF MILES
0 1 2

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SAN JOAQUIN COUNTY INVESTIGATION
CAMANCHE PROJECT
1953

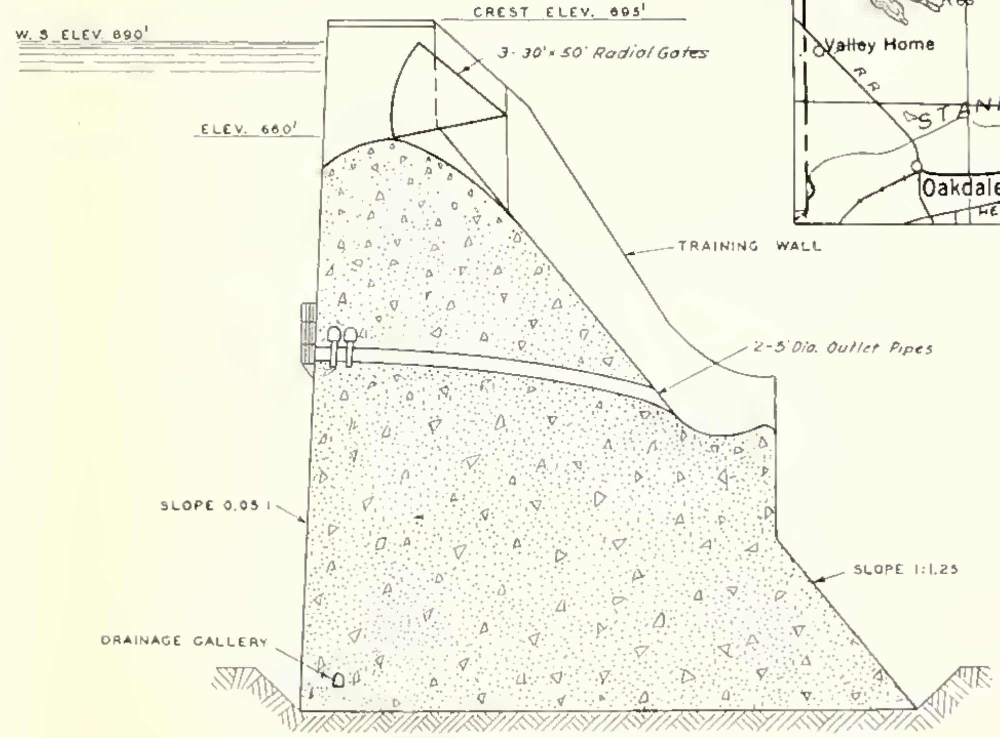


GENERAL PLAN
SCALE OF FEET
0 50 100



PROFILE OF DAM
LOOKING UPSTREAM

PROJECT AREA
SCALE OF MILES
4 0 4 8

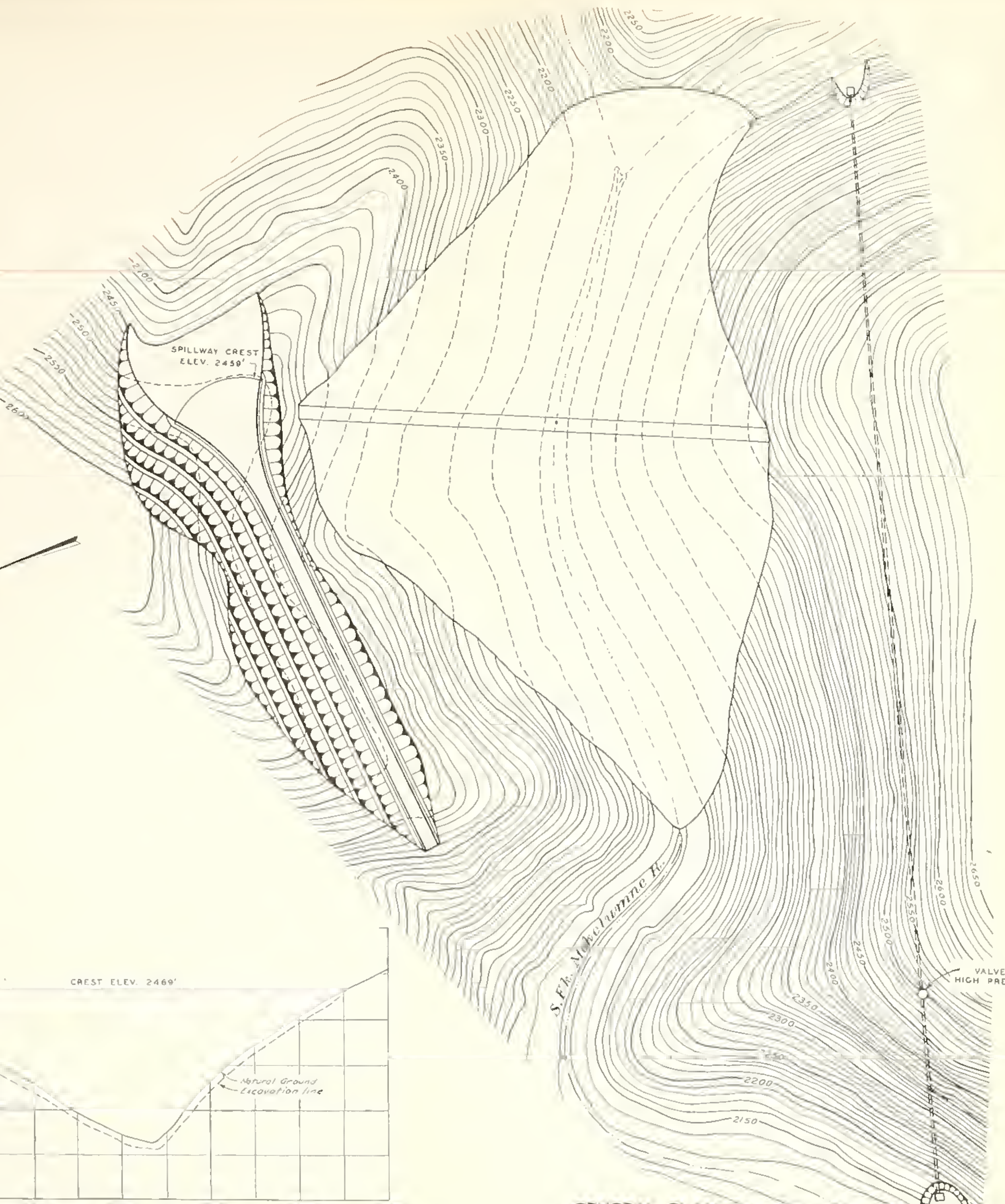


SECTION OF DAM
SCALE OF FEET
0 50 100

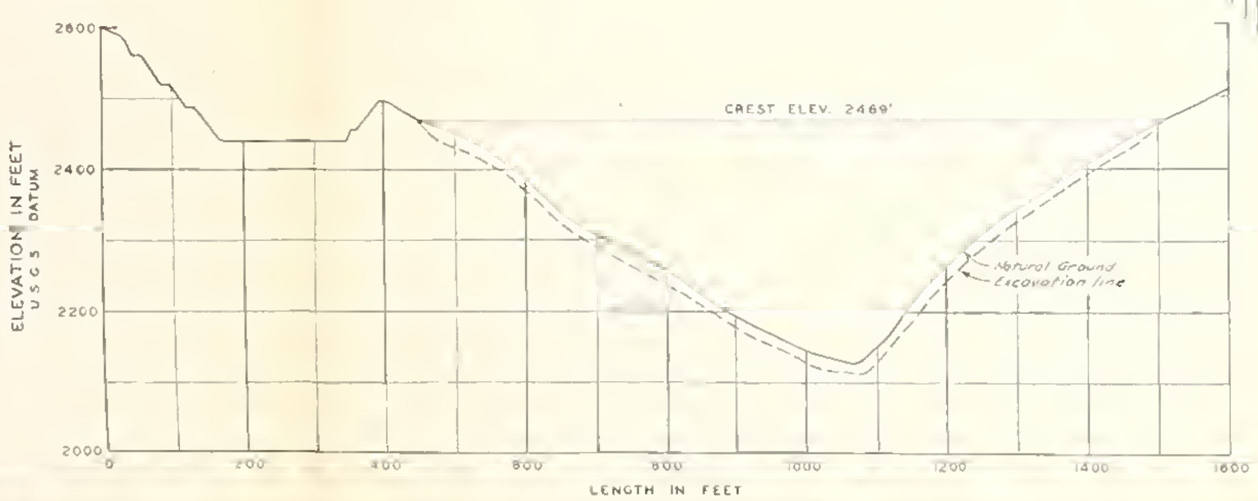
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

MIDDLE BAR PROJECT
1953

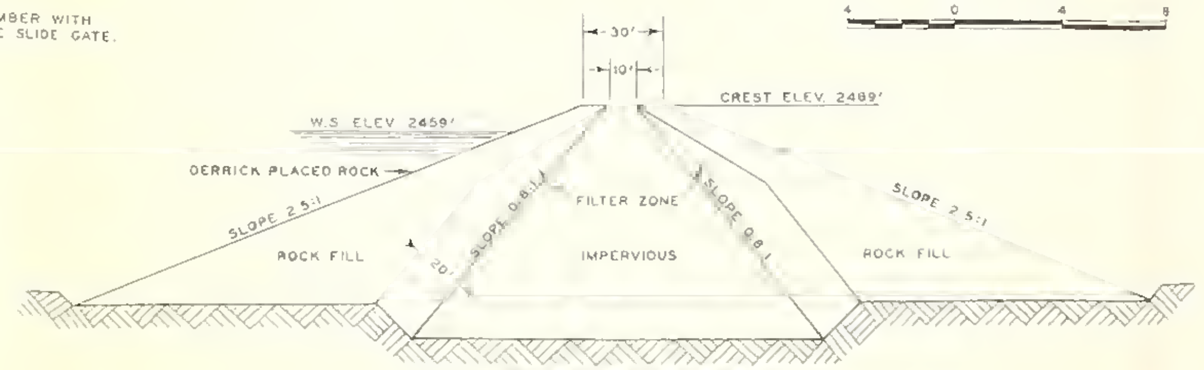


GENERAL PLAN
SCALE OF FEET
100 0 100 200 300 400



PROFILE OF DAM
LOOKING UPSTREAM

PROJECT AREA
SCALE OF MILES
4 0 4 8



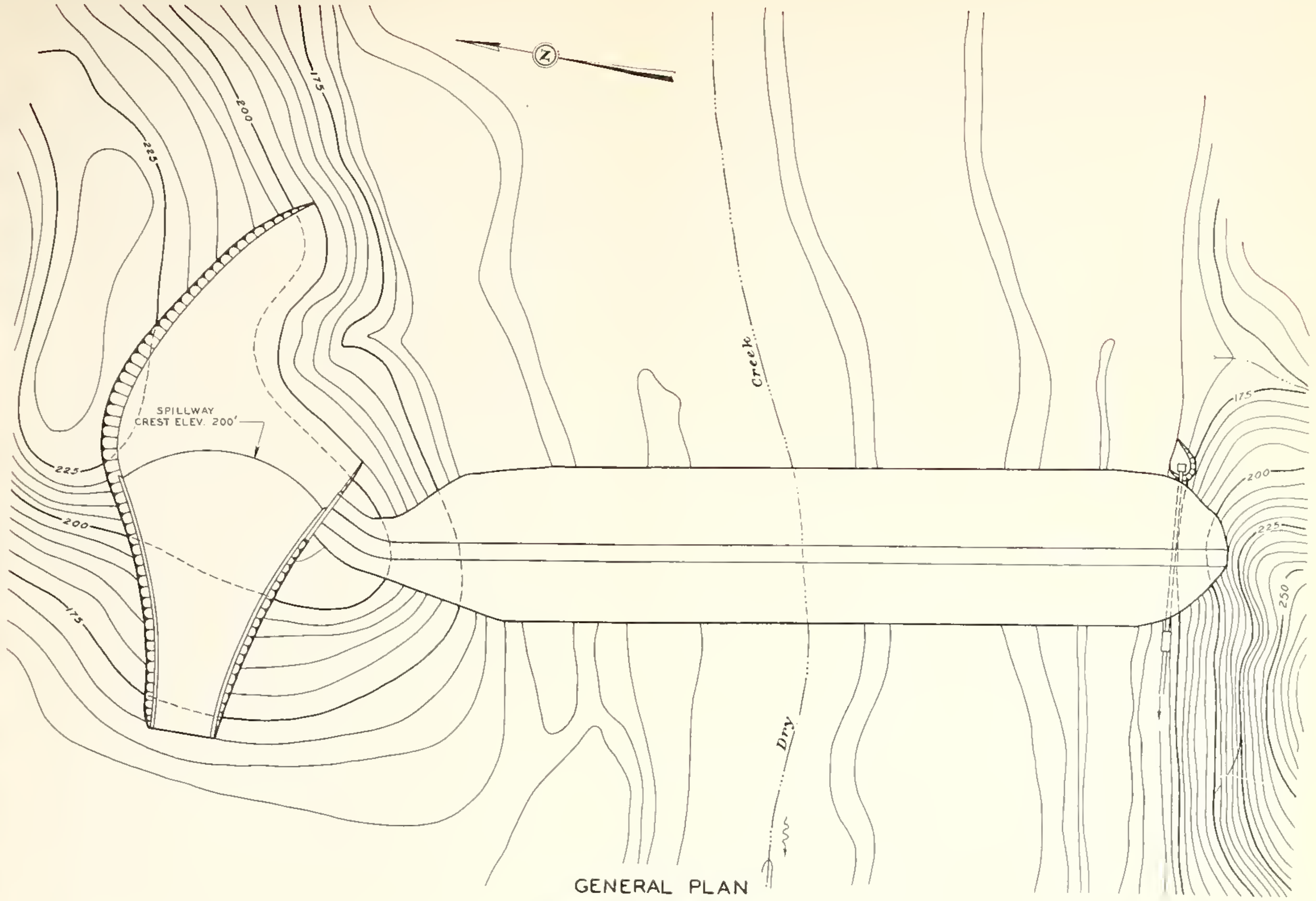
SECTION OF DAM
SCALE OF FEET
0 40 80

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

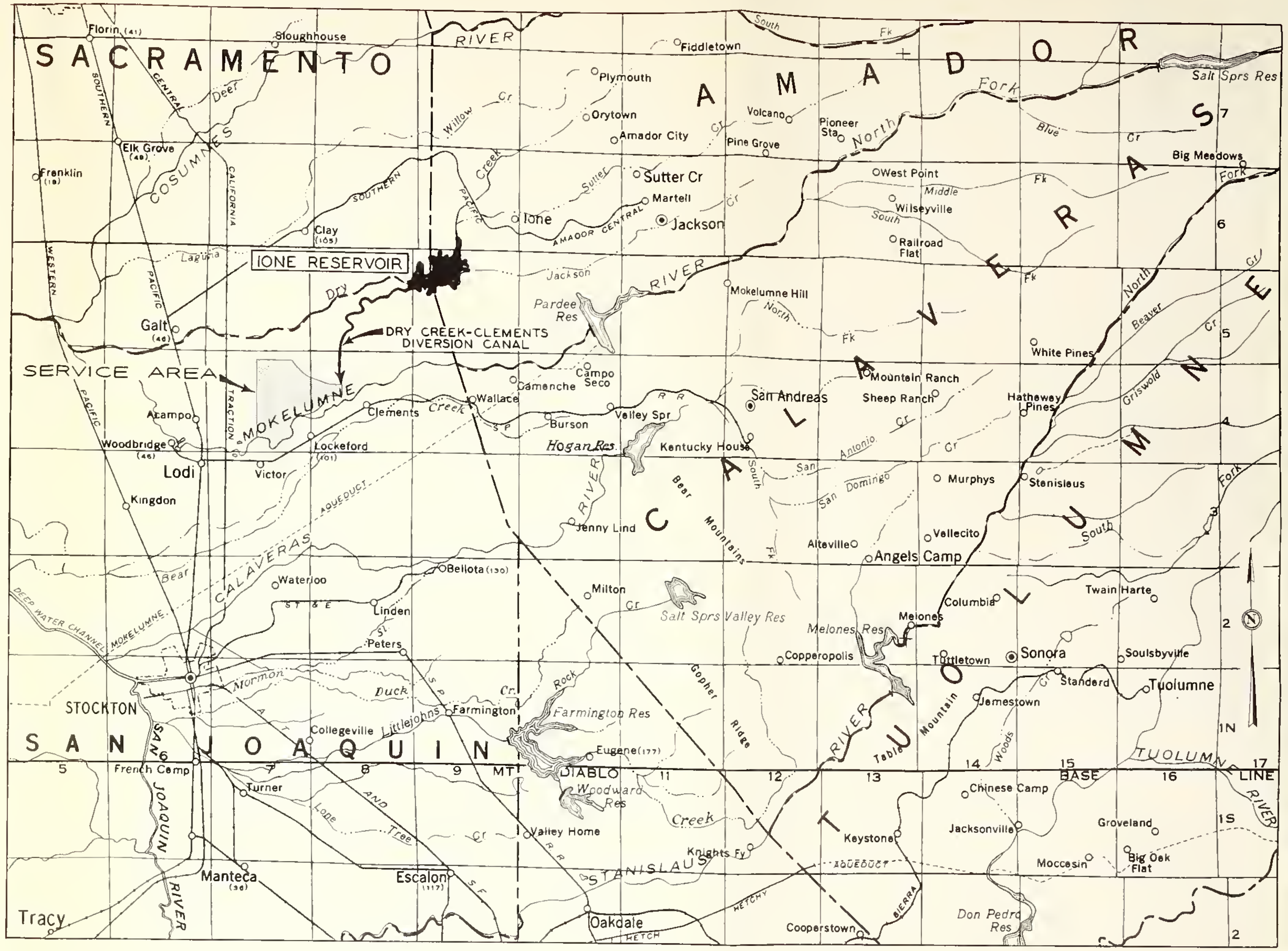
SAN JOAQUIN COUNTY INVESTIGATION

RAILROAD FLAT PROJECT

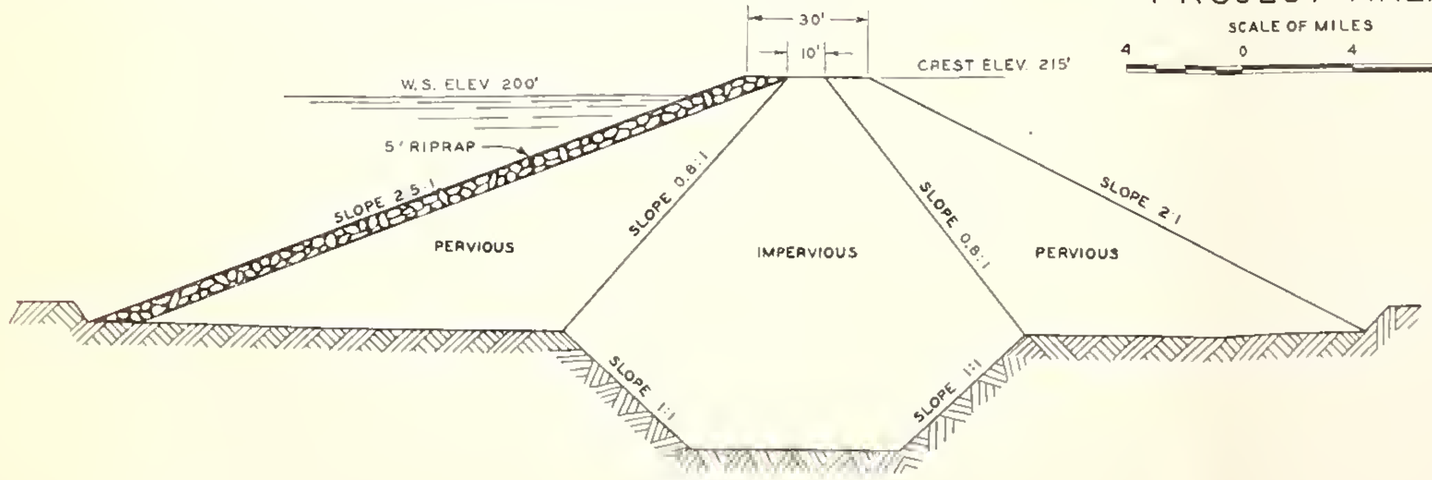
1953



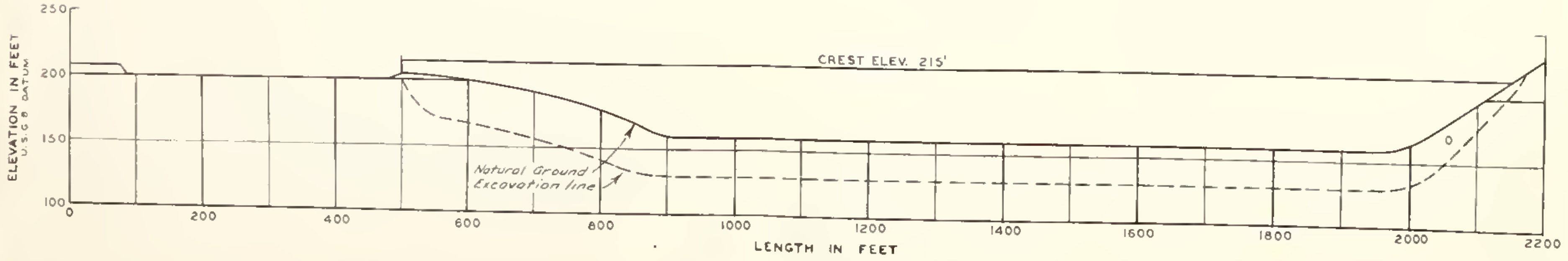
GENERAL PLAN
SCALE OF FEET
0 200 400



PROJECT AREA
SCALE OF MILES
4 0 4 8



SECTION OF DAM
SCALE OF FEET
0 30 60

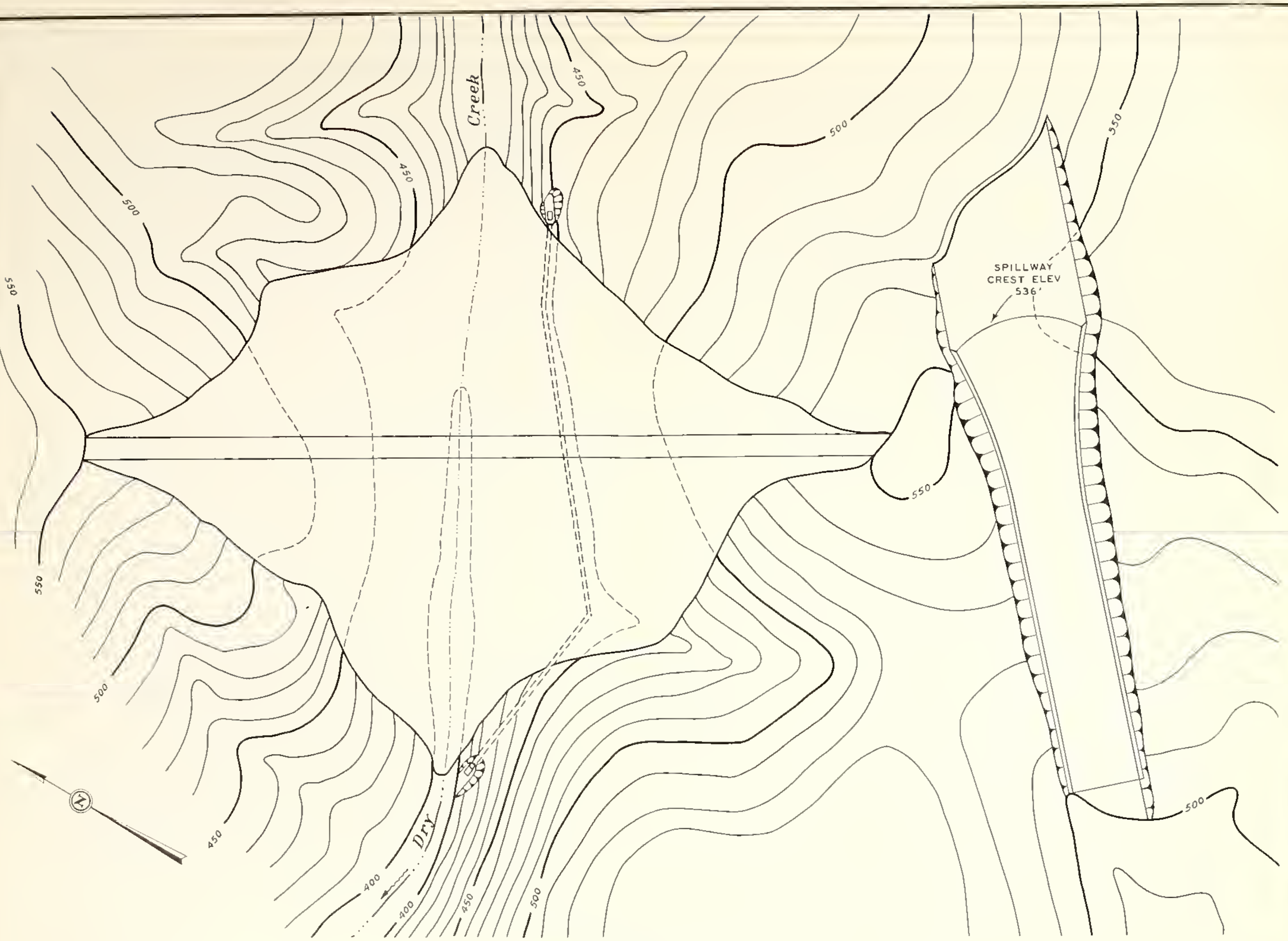


PROFILE OF DAM
LOOKING UPSTREAM

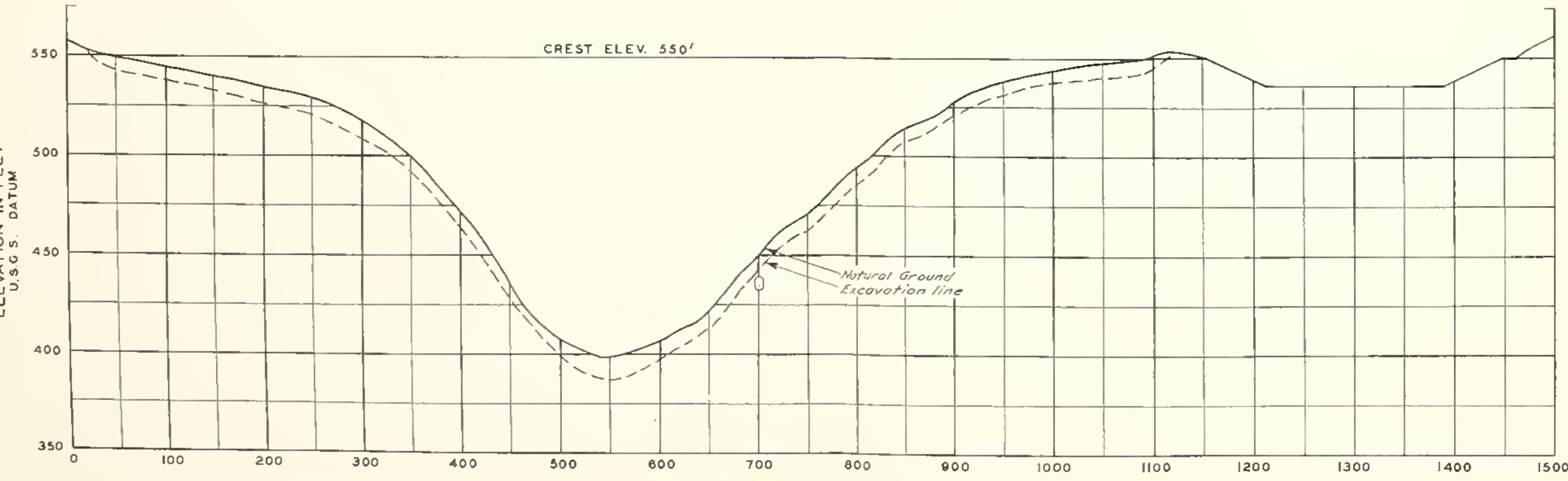
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

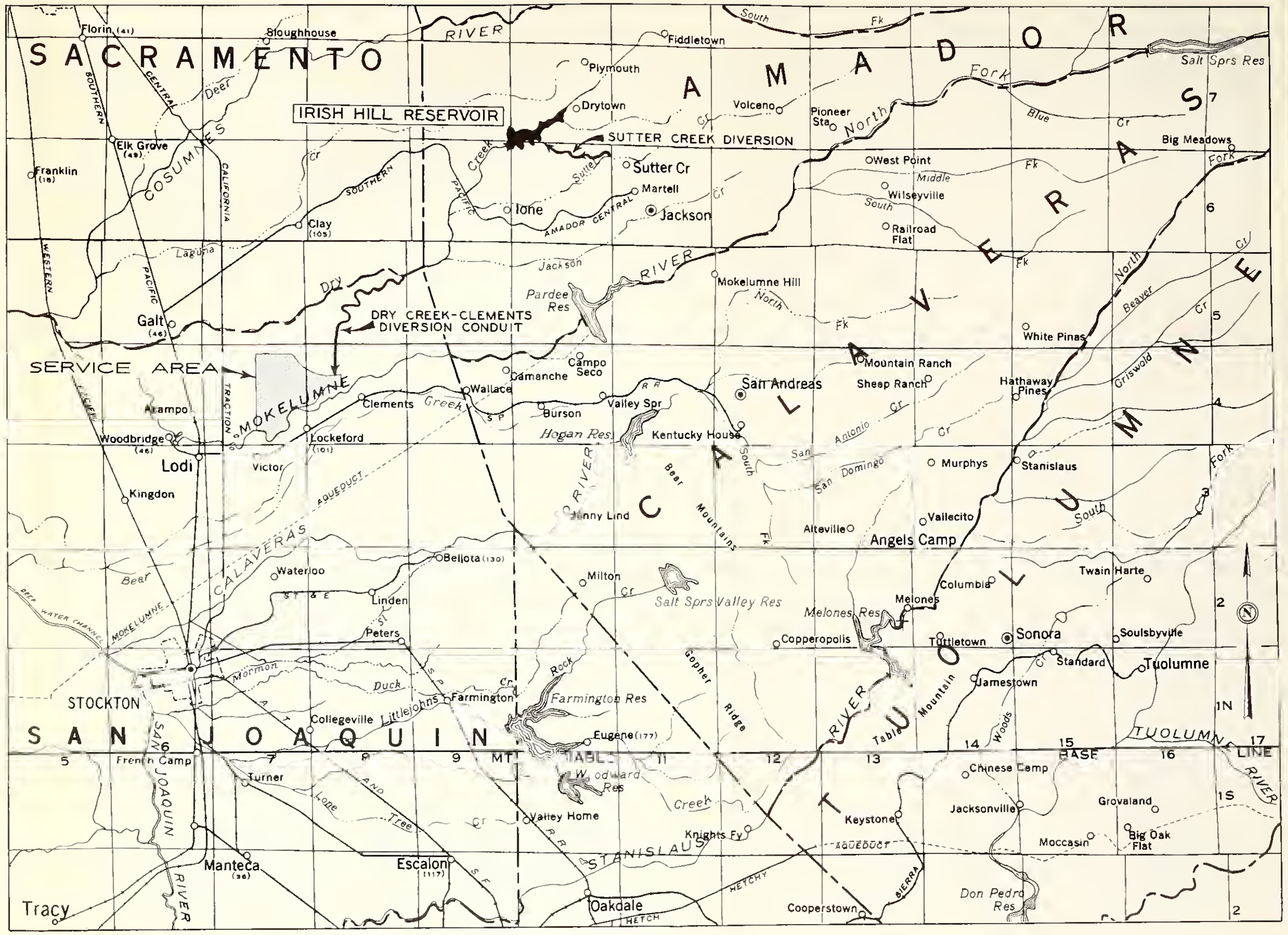
IONE PROJECT
1953



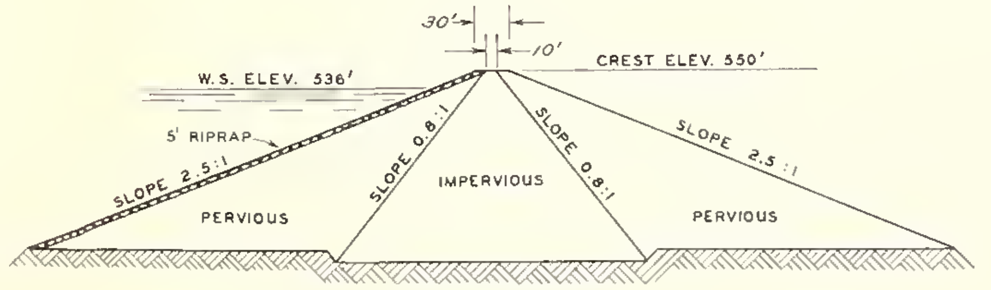
GENERAL PLAN
SCALE OF FEET
0 100 200



LENGTH IN FEET
PROFILE OF DAM
LOOKING UPSTREAM



PROJECT AREA
SCALE OF MILES
4 0 4 8



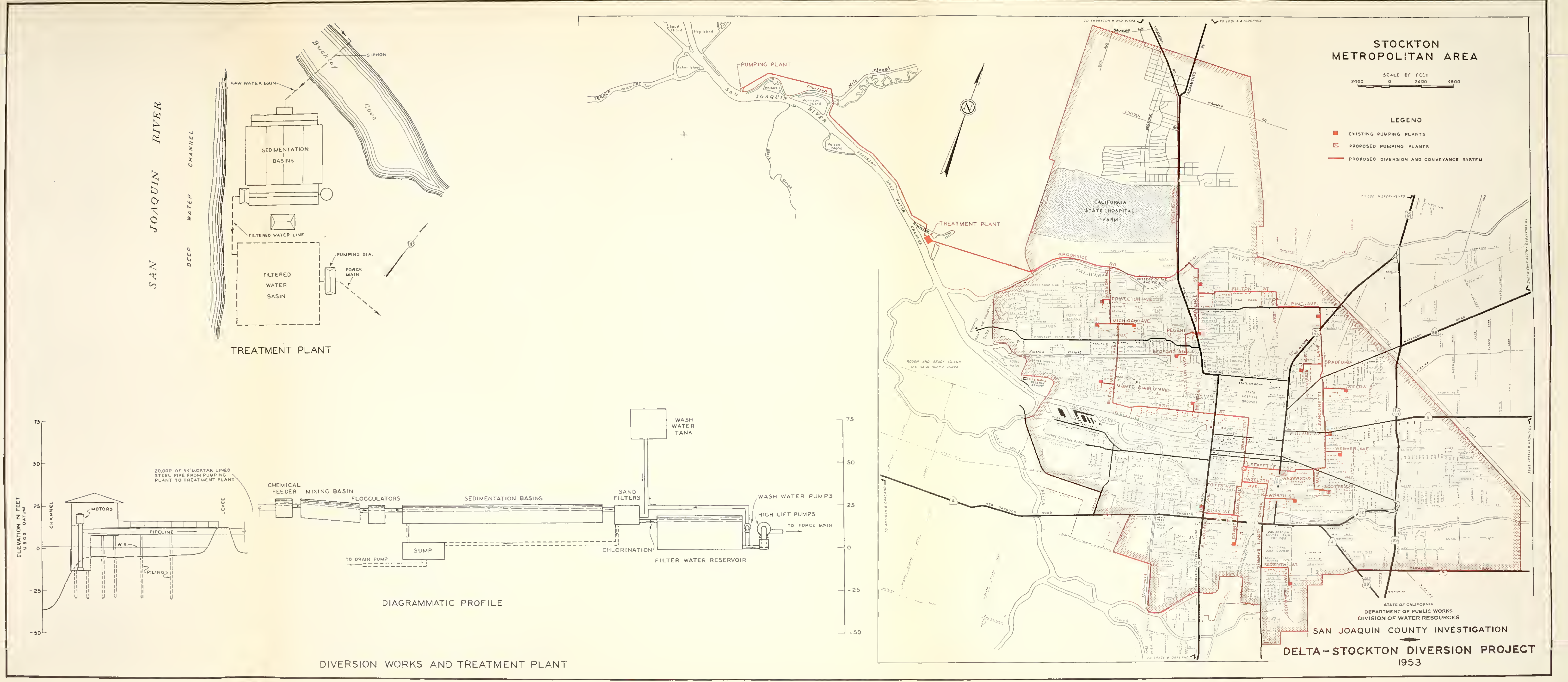
SECTION OF DAM
SCALE OF FEET
0 100 200

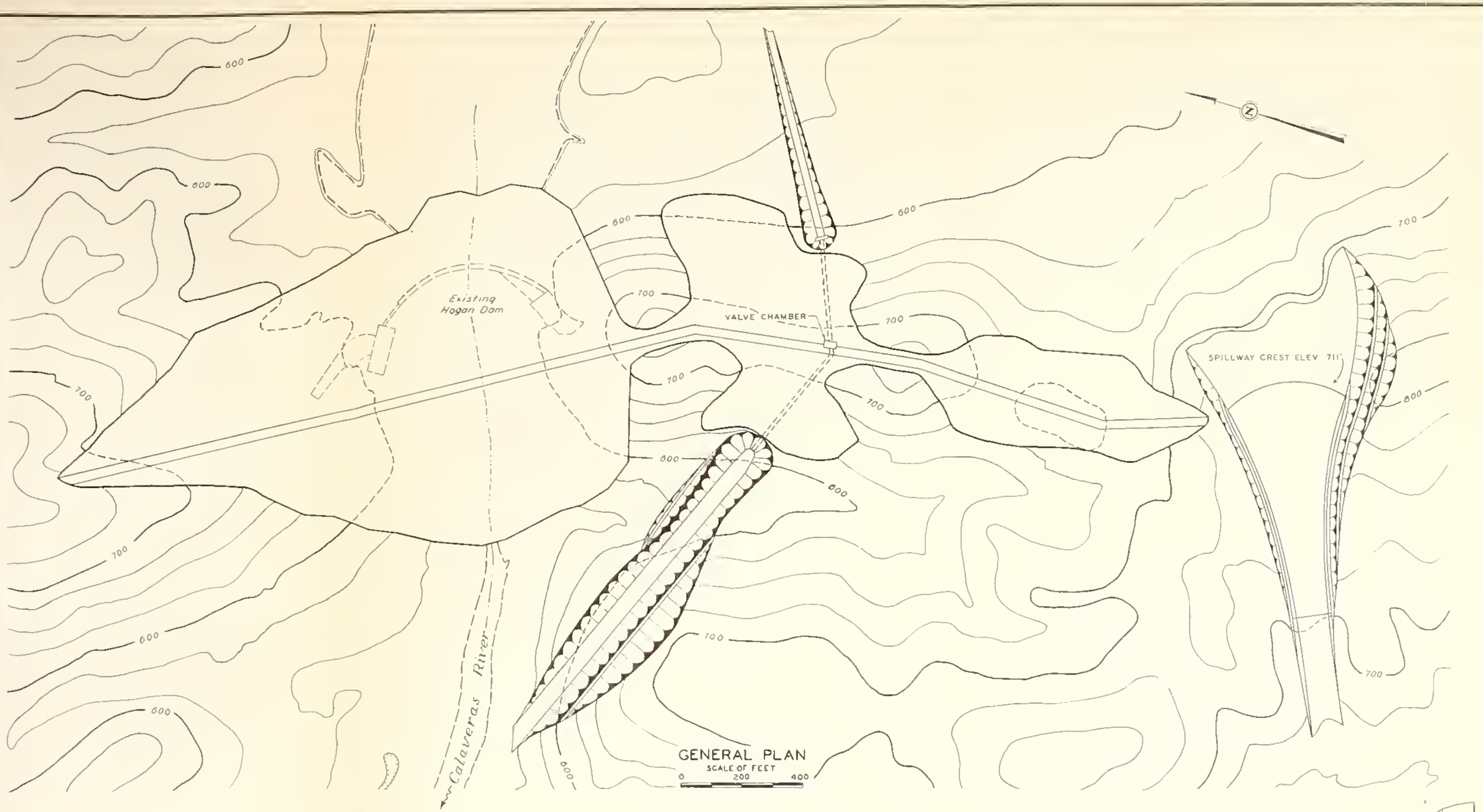
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

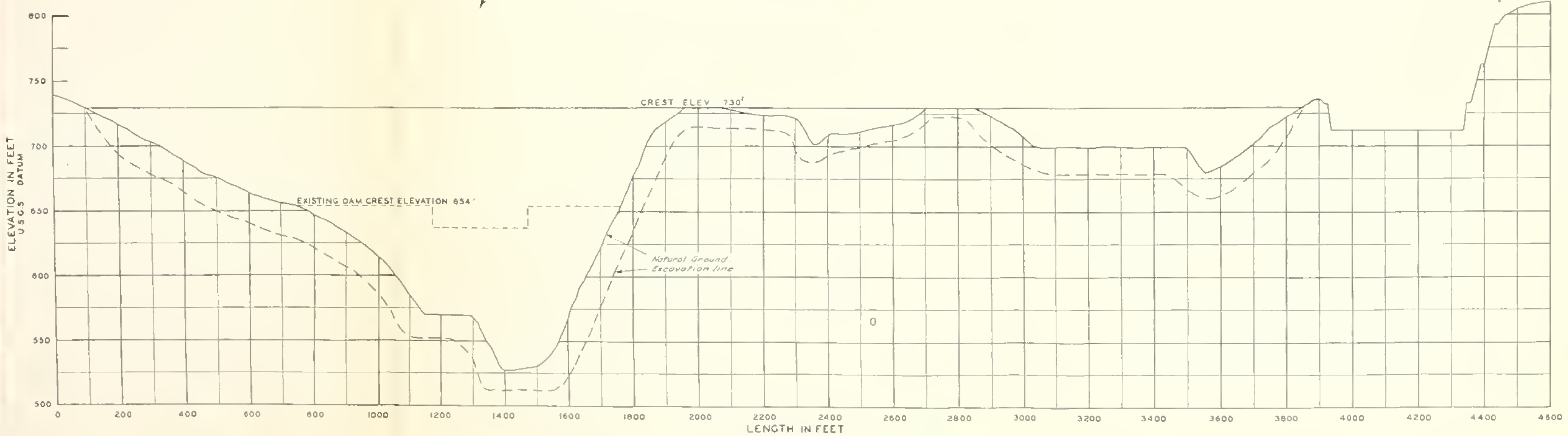
IRISH HILL PROJECT
1953

PLATE 24

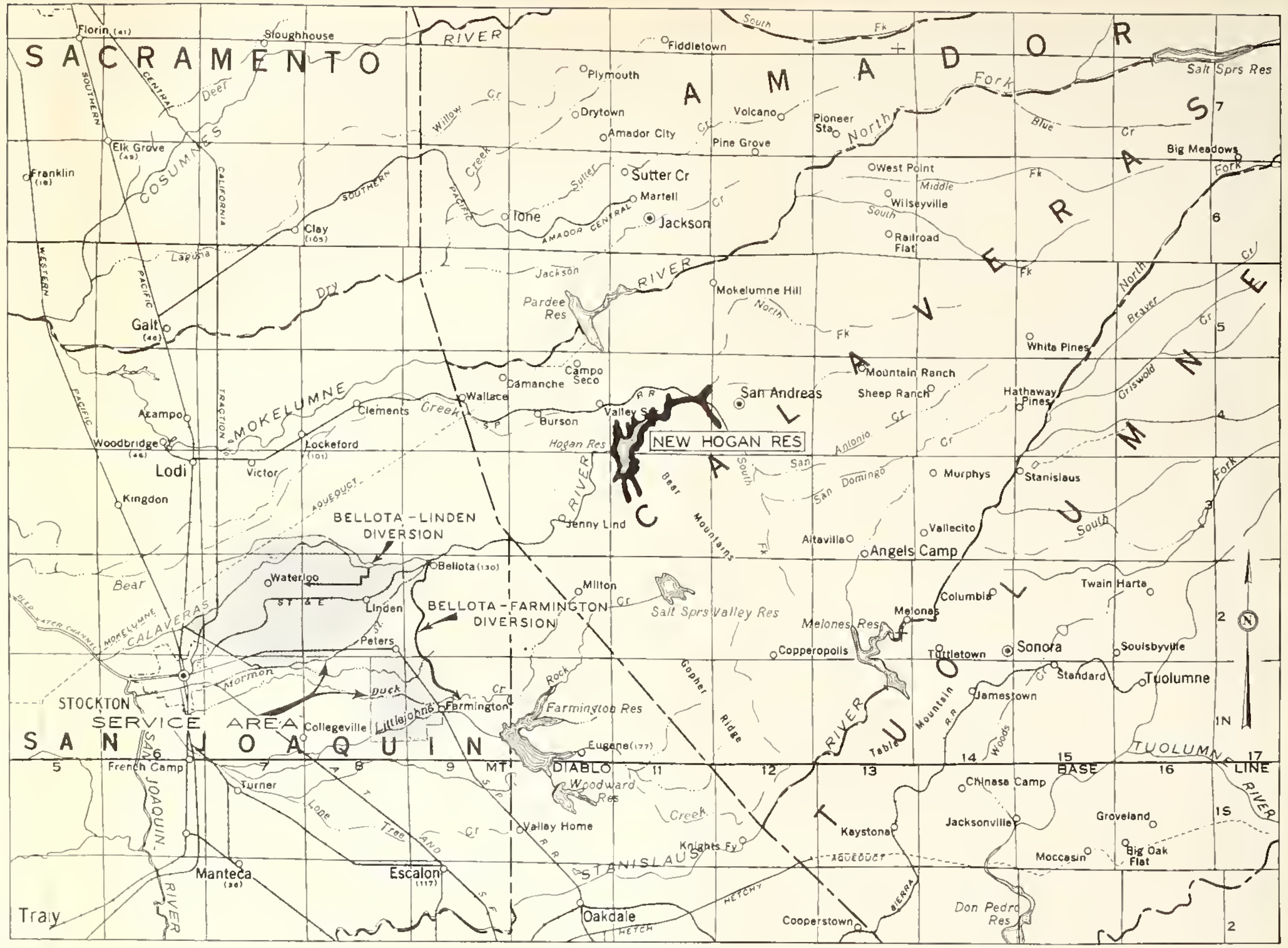

TREATMENT PLANT
SAN JOAQUIN RIVER
DEEP WATER CHANNEL
Buckley Cove
SIPHON
RAW WATER MAIN
SEDIMENTATION BASINS
FILTERED WATER LINE
FILTERED WATER BASIN
PUMPING STA
FORCE MAIN
DIAGRAMMATIC PROFILE
ELEVATION IN FEET U.S.G.S. DATUM
CHANNEL
MOTORS
LEVEE
PIPELINE
W.S.
PILING
20,000' OF 54" MORTAR LINED STEEL PIPE FROM PUMPING PLANT TO TREATMENT PLANT
CHEMICAL FEEDER
MIXING BASIN
FLOCCULATORS
SEDIMENTATION BASINS
SAND FILTERS
WASH WATER TANK
WASH WATER PUMPS
HIGH LIFT PUMPS
TO FORCE MAIN
SUMP
TO DRAIN PUMP
CHLORINATION
FILTER WATER RESERVOIR
DIVERSION WORKS AND TREATMENT PLANT
PUMPING PLANT
TREATMENT PLANT
SAN JOAQUIN RIVER
STOCKTON DEEP WATER CHANNEL
Fourteen Mile Slough
CALIFORNIA STATE HOSPITAL FARM
STOCKTON METROPOLITAN AREA
SCALE OF FEET
2400 0 2400 4800
LEGEND
EXISTING PUMPING PLANTS
PROPOSED PUMPING PLANTS
PROPOSED DIVERSION AND CONVEYANCE SYSTEM
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SAN JOAQUIN COUNTY INVESTIGATION
DELTA-STOCKTON DIVERSION PROJECT
1953



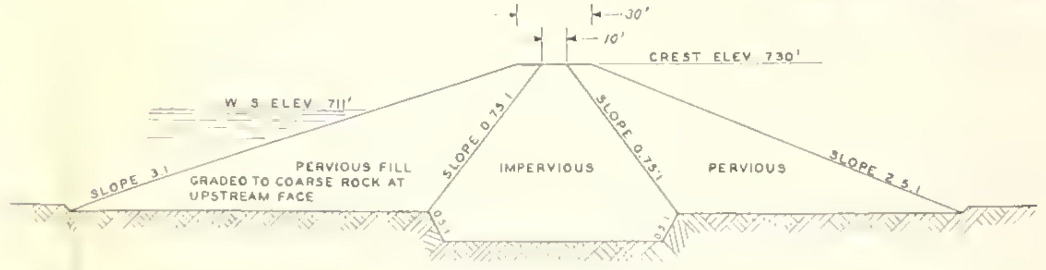
GENERAL PLAN
SCALE OF FEET
0 200 400



PROFILE OF DAM
LOOKING UPSTREAM



PROJECT AREA
SCALE OF MILES
4 0 4 8



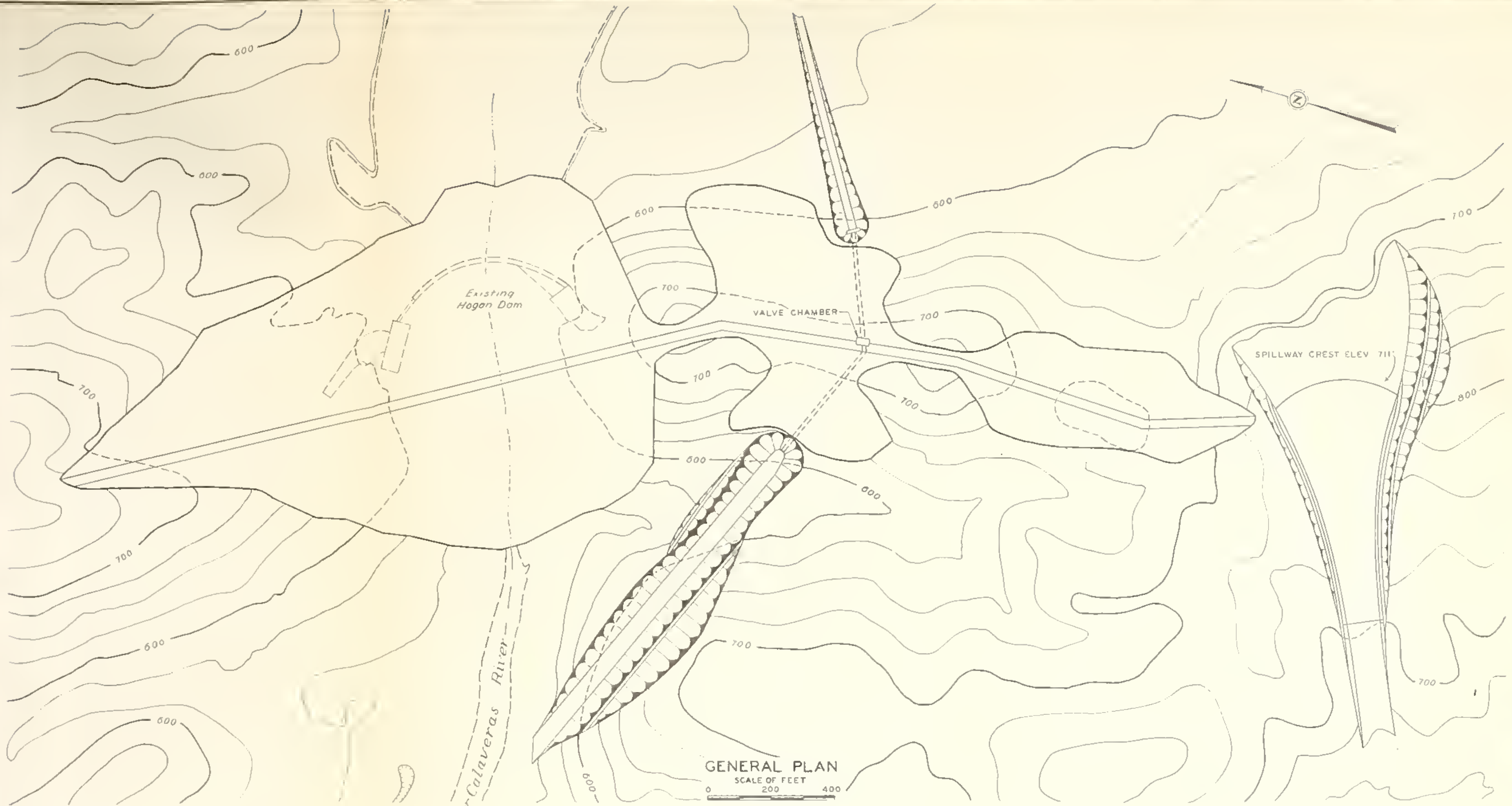
SECTION OF DAM
SCALE OF FEET
0 50 100

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

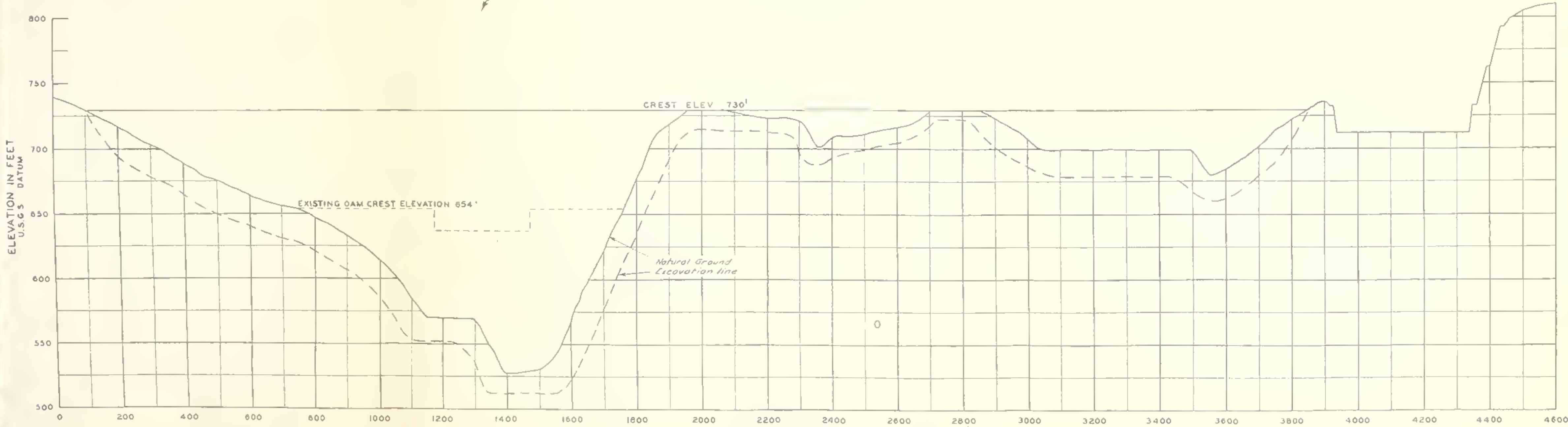
SAN JOAQUIN COUNTY INVESTIGATION

NEW HOGAN PROJECT

1953

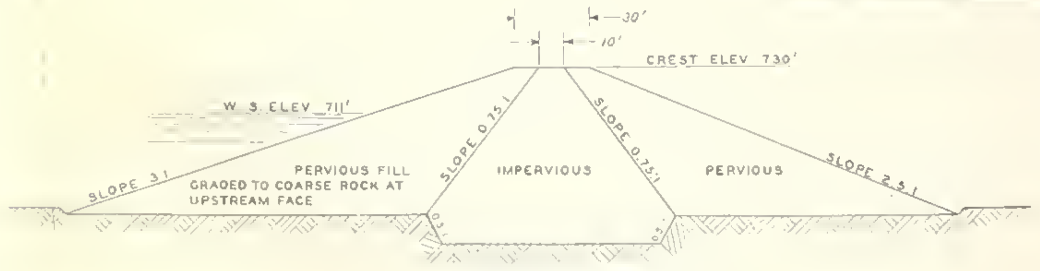


GENERAL PLAN
SCALE OF FEET
0 200 400



LENGTH IN FEET
PROFILE OF DAM
LOOKING UPSTREAM

PROJECT AREA
SCALE OF MILES
4 0 4 8



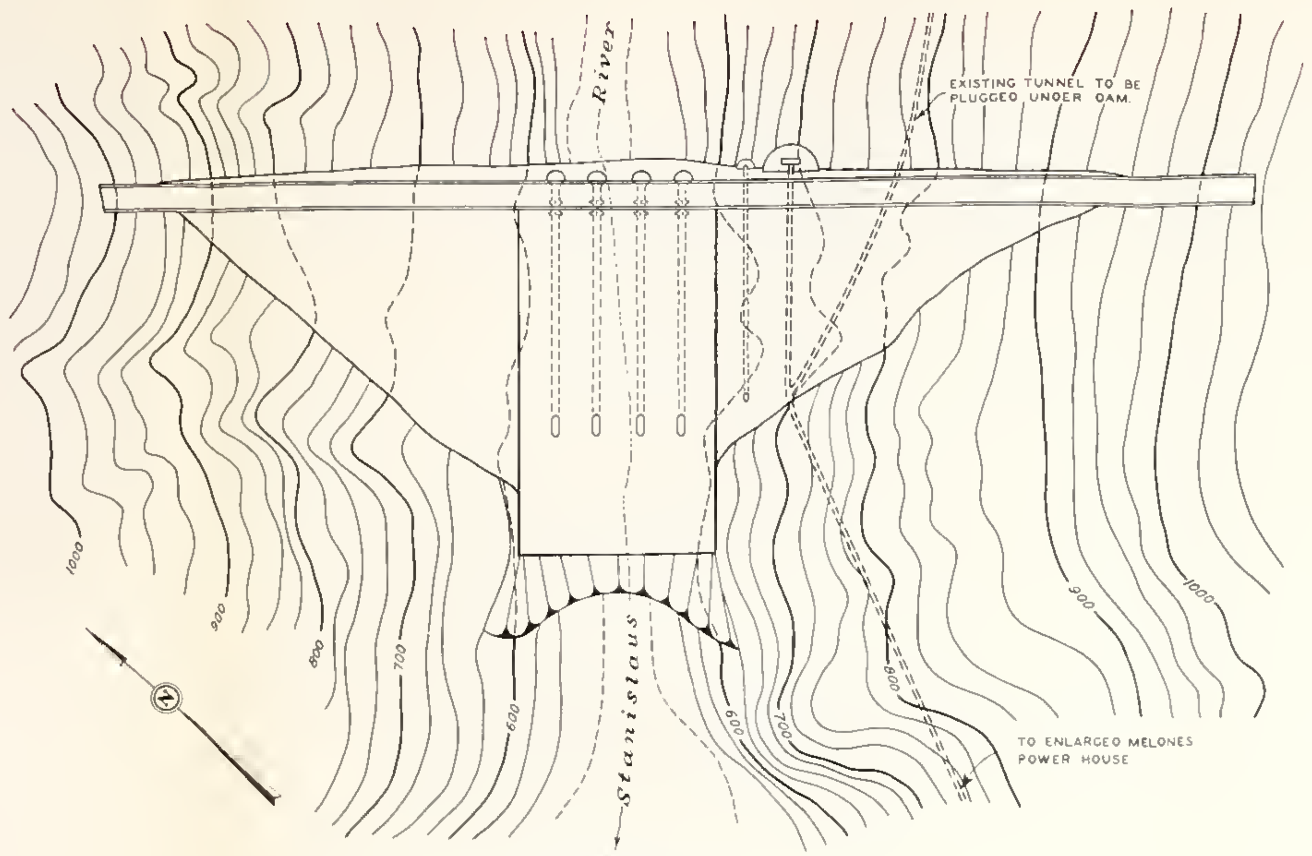
SECTION OF DAM
SCALE OF FEET
0 50 100

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

NEW HOGAN PROJECT

1953



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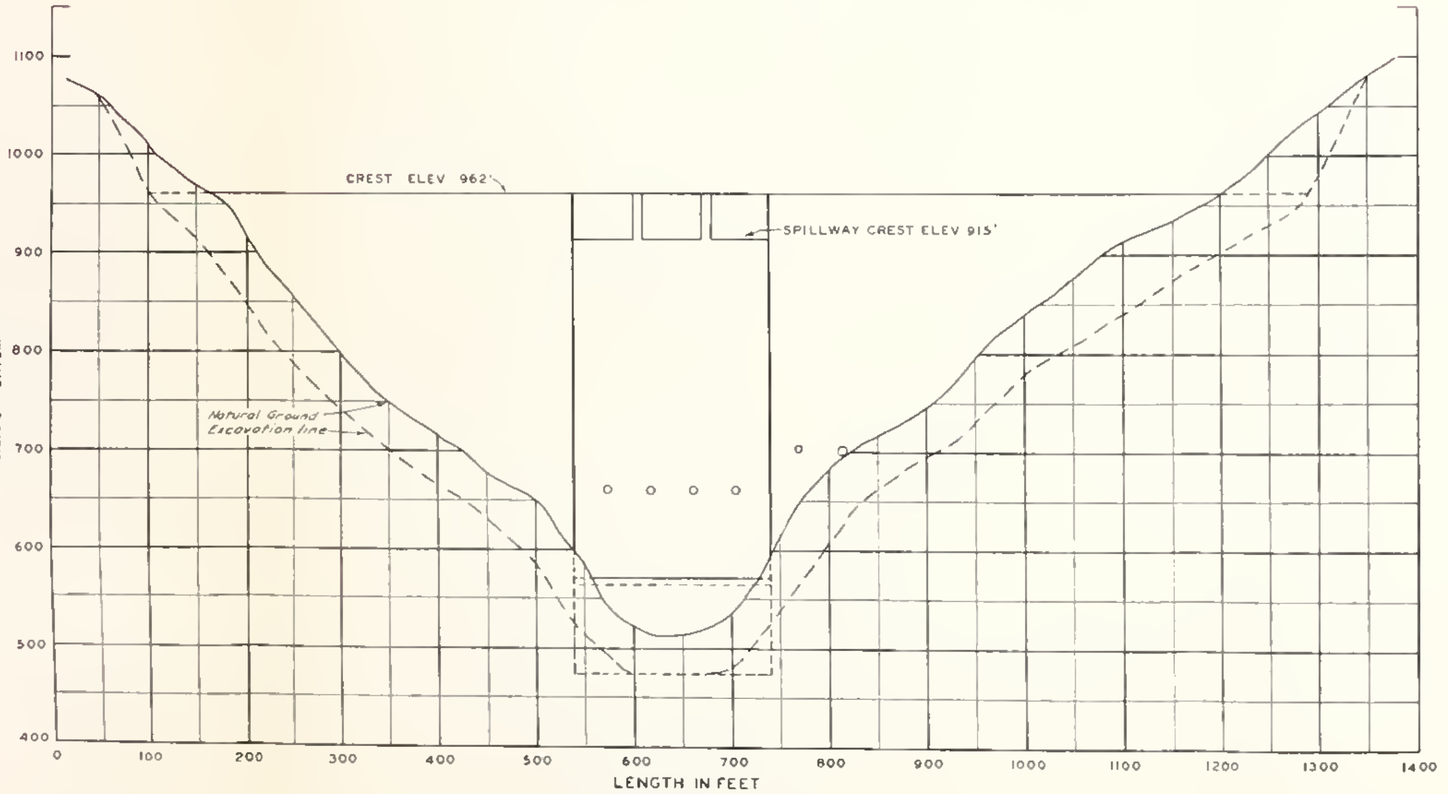
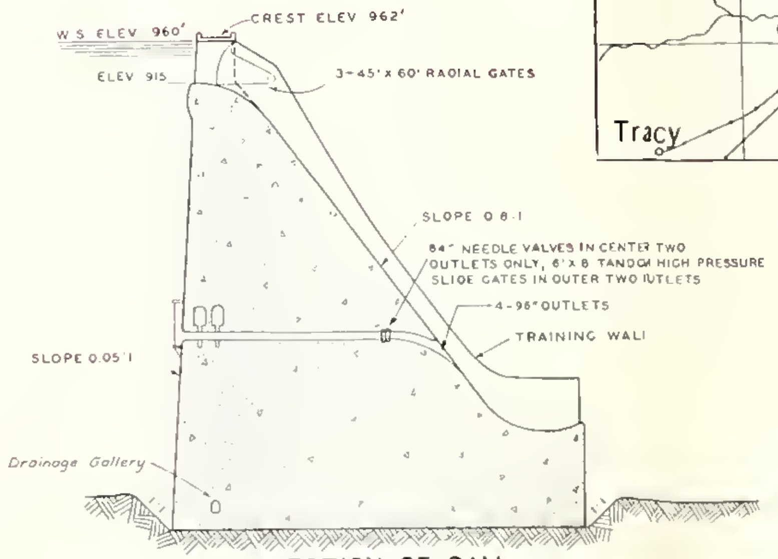


PROFILE OF DAM
LOOKING UPSTREAM



SECTION OF DAM
SCALE OF FEET
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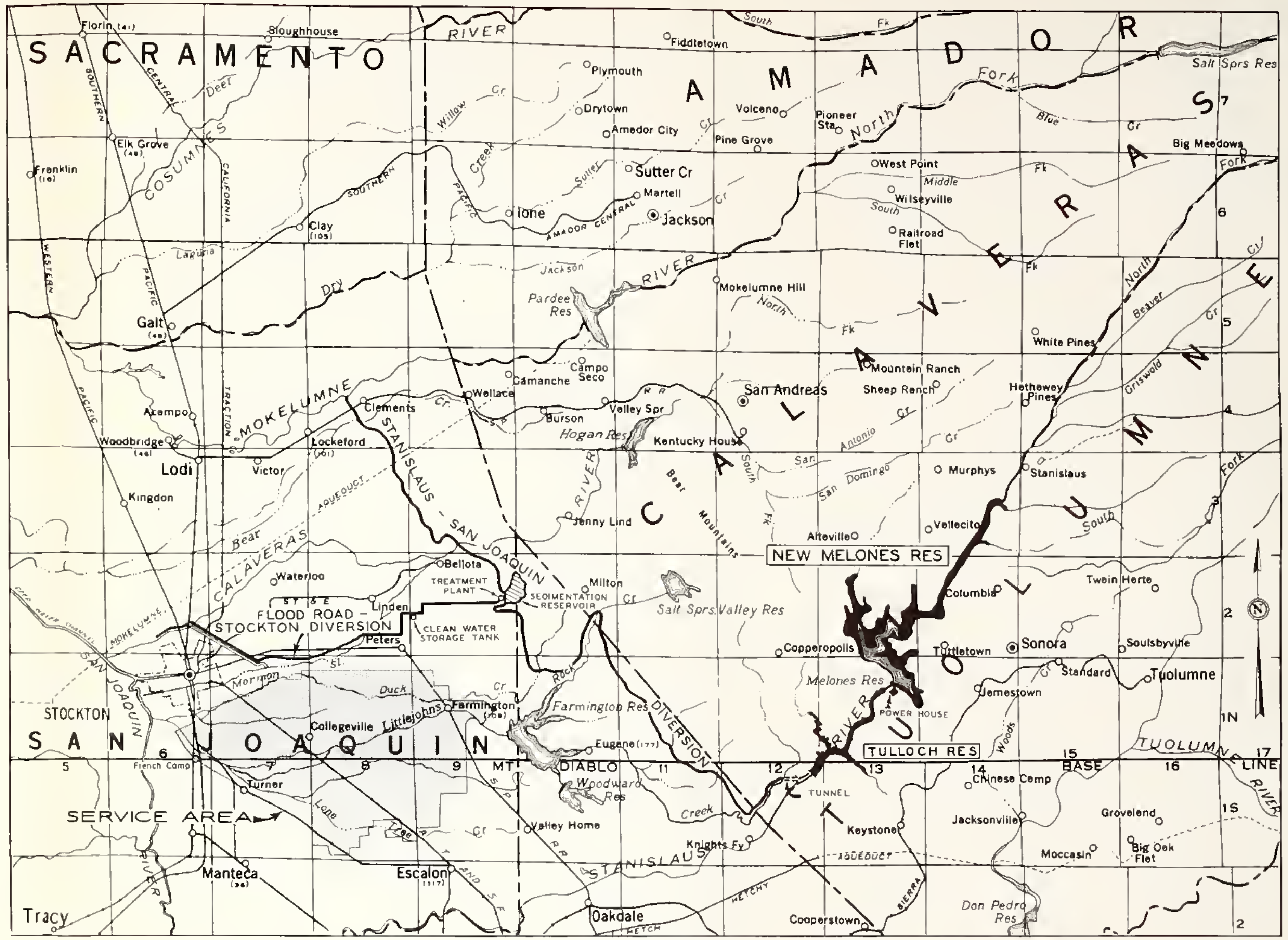

PROJECT AREA
SCALE OF MILES
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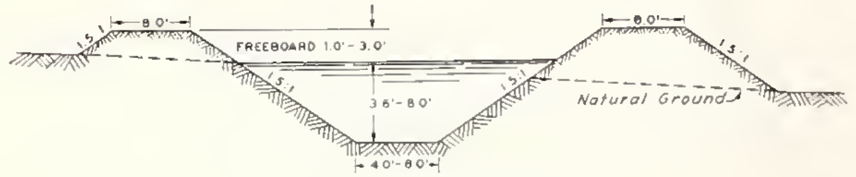

TYPICAL CANAL SECTION

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

SAN JOAQUIN COUNTY INVESTIGATION

NEW MELONES PROJECT
1953

APPENDIX A

AGREEMENTS

6—19144

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AGREEMENTS

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Agreement Between the State Water Resources Board, the Stockton-East San Joaquin Water Conservation District, and the Department of Public Works

AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE COUNTY OF SAN JOAQUIN AND THE DEPARTMENT OF PUBLIC WORKS

THIS AGREEMENT, executed in quadruplicate, entered into by the State Water Resources Board, hereinafter referred to as the "Board"; the County of San Joaquin, hereinafter referred to as the "County"; and the Department of Public Works, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer":

WITNESSETH:

WHEREAS, by the State Water Resources Act of 1945, as amended, the Board is authorized to make investigations, studies, surveys, hold hearings, prepare plans and estimates, and make recommendations to the Legislature in regard to water development projects, including flood control plans and projects; and

WHEREAS, by said act, the State Engineer is authorized to cooperate with any county, city, State agency or public district on flood control and other water problems and when requested by any thereof may enter into a cooperative agreement to expend money in behalf of any thereof to accomplish the purposes of said act; and

WHEREAS, the County desires and hereby requests the Board to enter into a cooperative agreement for the making of an investigation and report on the underground water supply in the Calaveras River Area, bounded approximately by Bellota on the east, the San Joaquin River on the west, Duck Creek on the south, and Bear Creek on the north, in the County of San Joaquin, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved; and

WHEREAS, the Board hereby requests the State Engineer to cooperate in making an investigation and report on the underground water supply in said Calaveras River Area, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved;

NOW THEREFORE, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the County, and the State Engineer do hereby mutually agree as follows:

ARTICLE I—WORK TO BE PERFORMED:

The work to be performed under this agreement shall consist of investigation and report on the underground water supply in the Calaveras River Area, bounded approximately by Bellota on the east, the San Joaquin River on the west, Duck Creek on the south, and Bear Creek on the north, in the County of San Joaquin, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved.

The Board by this agreement authorizes and directs the State Engineer to cooperate by making said investigation and report and by otherwise advising and assisting in making an evaluation of present and ultimate underground water problems in said Calaveras River Area, and in formulating a solution or solutions of the water problems thereof.

During the progress of said investigation and report all maps, plans, information, data and records pertaining thereto which are in the possession of any party hereto shall be made fully available to any other party for the due and proper accomplishment of the purposes and objects hereof.

The work under this agreement shall be diligently prosecuted with the objective of completion of the investigation and report on or before March 1, 1950, or as nearly thereafter as possible.

ARTICLE II—FUNDS:

The County, upon execution by it of this agreement, shall transmit to the State Engineer the sum of Seven Thousand Dollars ($7,000) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement. Also, upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of Seven Thousand Dollars ($7,000) from funds appropriated for the support of the Board by the Budget Act of 1947, for expenditure by the State Engineer in performance of the work provided for in this agreement and the State Controller will be requested to make such transfer.

If the Director of Finance, within thirty (30) days after receipt by the State Engineer of said Seven Thousand Dollars ($7,000) from the County, shall not have approved the deposit thereof into said Water Resources Revolving Fund, together with the transfer of the sum of Seven Thousand Dollars ($7,000) from funds appropriated for the support of the Board by the Budget Act of 1947, for expenditure by the State Engineer in performance of the work provided for in this agreement, said sum contributed by the County shall be returned thereto by the State Engineer.

It is understood by and between the parties hereto that the sum of Fourteen Thousand Dollars ($14,000) to be made available as hereinbefore provided is adequate to perform approximately half of the above specified work and it is the understanding that either the County or an appropriate local agency will make a further sum of Seven Thousand Dollars ($7,000) available at the commencement of the second year of said investigation which will be subject to a matching or contribution in an equal sum by the Board for the completion of said investigation and report.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the sum of Fourteen Thousand Dollars ($14,000) as made available hereunder and when said sum is exhausted, the Board and the State Engineer may discontinue the work provided for in this agreement and shall not be liable or responsible for the resumption and completion thereof until further sums as specified in the preceding paragraph are made available.

Upon completion of and final payment for the work provided for in this agreement, the State Engineer shall furnish to the Board and to the County a statement of all expenditures made under this agreement. One-half of the total amount of all said expenditures shall be deducted from the sum advanced from funds appropriated to said Board, and one-half of the total amount of all said expenditures shall be deducted from the sum advanced by the County and any balance which may remain shall be returned to the Board, and to the County, in equal amount.

ARTICLE III—EFFECTIVE DATE

This agreement shall become effective immediately upon its execution by all the parties hereto.

IN WITNESS WHEREOF, the parties hereunto have affixed their signatures, the County of San Joaquin on the 26th day of January, 1948, the Board on the 19th day of February, 1948, and the State Engineer on the 11th day of February, 1948.

Approval Recommended:

/s/ SPENCER BURROUGHS
Principal Attorney
Division of Water Resources

Approved as to Form:

/s/ FREDERICK L. FELTON
County Counsel
County of San Joaquin

Approved:

/s/ JAMES S. DEAN
Director of Finance

Approved as to Legality:

/s/ C. C. CARLETON
Chief Attorney
Department of Public Works

COUNTY OF SAN JOAQUIN

By /s/ W. R. RUGGLES
Chairman, Board of Supervisors

[SEAL]

/s/ R. E. GRAHAM
Clerk, Board of Supervisors

STATE WATER RESOURCES BOARD

By /s/ ROYAL MILLER
Chairman

DEPARTMENT OF PUBLIC WORKS
STATE OF CALIFORNIA

[SEAL]

By /s/ C. H. PURCELL
Director of Public Works

/s/ EDWARD HYATT
Edward Hyatt
State Engineer

SUPPLEMENTAL AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE COUNTY OF SAN JOAQUIN, AND THE DEPARTMENT OF PUBLIC WORKS

THIS AGREEMENT, executed in quintuplicate, entered into as of February 19, 1949, by the State Water Resources Board, hereinafter referred to as the "Board"; the County of San Joaquin, hereinafter referred to as the "County"; and the Department of Public Works of the State of California, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer."

WITNESSETH:

WHEREAS, by agreement heretofore entered into by and between the County of San Joaquin, the Board and the State Engineer, executed by the County on the 26th day of January, 1948, by the Board on the 19th day of February, 1948, and by the State Engineer on the 11th day of February, 1948, the making by the State Engineer of an investigation and report on the underground water supply in the Calaveras River Area, bounded approximately by Bellota on the east, the San Joaquin River on the west, Duck Creek on the south, and Bear Creek on the north, in the County of San Joaquin, including quality, replenishment and utilization thereof and, if possible, a method or methods of solving the problems involved, was provided for; and

WHEREAS, it was the expressed intention in said agreement that at the commencement of the second year of said investigation the County of San Joaquin, or an appropriate local agency, would make available a further sum of Seven Thousand Dollars ($7,000) subject to a matching or contribution in equal amount by the Board for the completion of said investigation and report; and

WHEREAS, the Stockton and East San Joaquin Water Conservation District, a local agency, was duly organized and is operating under the provisions of Chapter 1020 of the Statutes of 1931, known as the "Water Conservation Act of 1931," and said District includes the investigational area described in said prior agreement and said District is such an appropriate agency within the intent and meaning of said prior agreement, but said District has no funds available at this time for the completion of said investigation and report; and

WHEREAS, additional funds are required to complete said investigation and report, and it is the desire of the parties hereto that an additional sum of Fourteen Thousand Dollars ($14,000) shall be provided, Seven Thousand Dollars ($7,000) by the County, and Seven Thousand Dollars ($7,000) by the Board;

NOW THEREFORE, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the County, and the State Engineer do hereby mutually agree as follows:

1. The County, upon execution by it of this agreement, shall transmit to the State Engineer the sum of Seven Thousand Dollars ($7,000) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental.

2. Upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of Seven Thousand Dollars ($7,000) from funds appropriated to the Board by Item 335 of the Budget Act of 1948 for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental, and the State Controller will be requested to make such transfer.

3. The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for in said prior agreement to which this agreement is supplemental any amount in excess of the sum of Twenty-Eight Thousand Dollars ($28,000) as made available under said prior agreement and this supplemental agreement and if funds are exhausted before completion of said work the Board and the State Engineer may discontinue said work and shall not be liable or responsible for the completion thereof.

4. In so far as consistent herewith and to the extent adaptable hereto, all of the terms and provisions of said prior agreement to which this agreement is supplemental are hereby made applicable to this agreement and are hereby confirmed, ratified, and continued in effect.

IN WITNESS WHEREOF, the parties hereunto have affixed their signatures, the County on the 28th day of February, 1949, the Board of the 14th day of March, 1949, and the State Engineer on the 23rd day of March, 1949.

Approved as to form:

/s/ FREDERICK L. FELTON
County Counsel,
County of San Joaquin

Approval Recommended:

/s/ HENRY HOLSINGER
Principal Attorney
Division of Water Resources

Approval Recommended:

/s/ C. R. MONTGOMERY
Chief Attorney
Department of Public Works

Approved:

/s/ JAMES S. DEAN
Director of Finance

COUNTY OF SAN JOAQUIN

By W. R. RUGGLES /s/
Chairman, Board of Supervisors

R. E. GRAHAM /s/
Clerk, Board of Supervisors

STATE WATER RESOURCES BOARD

By /s/ C. A. GRIFFITH
Chairman

DEPARTMENT OF PUBLIC WORKS
STATE OF CALIFORNIA

By /s/ C. H. PURCELL
Director of Public Works

/s/ EDWARD HYATT
Edward Hyatt
State Engineer

C.C.B. Form	F.J.M. Budget	Value	Descript.

DEPARTMENT OF FINANCE

APPROVED

Apr 8 1949

AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE COUNTY OF SAN JOAQUIN AND THE DEPARTMENT OF PUBLIC WORKS

THIS AGREEMENT, executed in quadruplicate, entered into by the State Water Resources Board, hereinafter referred to as the "Board"; the County of San Joaquin, hereinafter referred to as the "County"; and the Department of Public Works, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer":

WITNESSETH:

WHEREAS, by the The State Water Resources Act of 1945, as amended, the Board is authorized to make investigations, studies, surveys, hold hearings, prepare plans and estimates, and make recommendations to the Legislature in regard to water development projects, including flood control plans and projects; and

WHEREAS, by said act, the State Engineer is authorized to cooperate with any county, city, State agency or public district on flood control and other water problems and when requested by any thereof may enter into a cooperative agreement to expend money in behalf of any thereof to accomplish the purposes of said act; and

WHEREAS, the County desires and hereby requests the Board to enter into a cooperative agreement for the making of an investigation and report on the underground water supply in the Mokelumne River Area, bounded approximately by Clements on the east, the San Joaquin River on the west, Bear Creek on the south, and Dry Creek on the north, in the County of San Joaquin, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved; and

WHEREAS, the Board hereby requests the State Engineer to cooperate in making an investigation and report on the underground water supply in said Mokelumne River Area, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved;

NOW THEREFORE, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the County, and the State Engineer do hereby mutually agree as follows:

ARTICLE I—WORK TO BE PERFORMED:

The work to be performed under this agreement shall consist of investigation and report on the underground water supply in the Mokelumne River Area, bounded approximately by Clements on the east, the San Joaquin River on the west, Bear Creek on the south, and Dry Creek on the north, in the County of San Joaquin, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved.

The Board by this agreement authorizes and directs the State Engineer to cooperate by making said investigation and report and by otherwise advising and assisting in making an evaluation of present and ultimate underground water problems in said Mokelumne River Area, and in formulating a solution or solutions of the water problems thereof.

During the progress of said investigation and report all maps, plans, information, data and records pertaining thereto which are in the possession of any party hereto shall be made fully available to any other party for the due and proper accomplishment of the purposes and objects hereof.

The work under this agreement shall be diligently prosecuted with the objective of completion of the investigation and report on or before July 1, 1950, or as nearly thereafter as possible.

ARTICLE II—FUNDS:

The County, upon execution by it of this agreement, shall transmit to the State Engineer the sum of Six Thousand Five Hundred Dollars ($6,500) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement. Also, upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of Six Thousand Five Hundred Dollars ($6,500) from funds appropriated to the Board by Item 335 of the Budget Act of 1948, for expenditure by the State Engineer in performance of the work provided for in this agreement and the State Controller will be requested to make such transfer.

If the Director of Finance, within thirty (30) days after receipt by the State Engineer of said Six Thousand Five Hundred Dollars ($6,500) from the County, shall not have approved the deposit thereof into said Water Resources Revolving Fund, together with the transfer of the sum of Six Thousand Five Hundred Dollars ($6,500) from funds appropriated to the Board by Item 335 of the Budget Act of 1948, for expenditure by the State Engineer in performance of the work provided for in this agreement, said sum contributed by the County shall be returned thereto by the State Engineer.

It is understood by and between the parties hereto that the sum of Thirteen Thousand Dollars ($13,000) to be made available as hereinbefore provided is adequate to perform approximately half of the above specified work and it is the understanding that either the County or an appropriate local agency will make a further sum of Six Thousand Dollars ($6,000) available at the commencement of the second year of said investigation which will be subject to a matching or contribution in an equal sum by the Board for the completion of said investigation and report.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the sum of Thirteen Thousand Dollars ($13,000) as made available hereunder and when said sum is exhausted, the Board and the State Engineer may discontinue the work provided for in this agreement and shall not be liable or responsible for the resumption and completion thereof until further sums as specified in the preceding paragraph are made available.

Upon completion of and final payment for the work provided for in this agreement, the State Engineer shall furnish to the Board and to the County a statement of all expenditures made under this agreement. One-half of the total amount of all said expenditures shall be deducted from the sum advanced from funds appropriated to said Board, and one-half of the total amount of all said expenditures shall be deducted from the sum advanced by the County and any balance which may remain shall be returned to the Board, and to the County, in equal amount.

ARTICLE III—EFFECTIVE DATE:

This agreement shall become effective on July 1, 1948, or upon its execution by all the parties hereto, whichever is the later date.

IN WITNESS WHEREOF, the parties hereunto have affixed their signatures, the County of San Joaquin on the 22nd day of November, 1948, the Board on the 3rd day of December, 1948, and the State Engineer on the 10th day of November, 1948.

Approval Recommended:

/s/ Henry Holsinger
Principal Attorney
Division of Water Resources

Approved as to Form:

/s/ Frederick L. Felton
County Counsel
County of San Joaquin

Approved:

/s/ James S. Dean
Director of Finance

Approved as to Legality:

/s/ C. C. Carleton
Chief Attorney
Department of Public Works

COUNTY OF SAN JOAQUIN

By /s/ W. R. Ruggles
Chairman, Board of Supervisors

/s/ R. E. Graham
Clerk, Board of Supervisors

/s/ By I. M. Golding
Deputy Clerk

STATE WATER RESOURCES BOARD

By /s/ C. A. Griffith
Chairman

DEPARTMENT OF PUBLIC WORKS
STATE OF CALIFORNIA

By /s/ C. H. Purcell
Director of Public Works

/s/ Edward Hyatt
Edward Hyatt
State Engineer

SUPPLEMENTAL AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE COUNTY OF SAN JOAQUIN, AND THE DEPARTMENT OF PUBLIC WORKS

THIS AGREEMENT, executed in quintuplicate, by the State Water Resources Board, hereinafter referred to as the "Board"; the County of San Joaquin, hereinafter referred to as the "County"; and the Department of Public Works of the State of California, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer."

WITNESSETH:

WHEREAS, by agreement heretofore entered into by and between the County, the Board and the State Engineer, executed by the County on the 22nd day of November, 1948, by the Board on the 3rd day of December, 1948, and by the State Engineer on the 10th day of November, 1948, the making by the State Engineer of an investigation and report on the underground water supply in the Mokelumne River area, bounded approximately by Clements on the east, the San Joaquin River on the west, Bear Creek on the south, and Dry Creek on the north, in the County of San Joaquin, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved, was provided for; and

WHEREAS, pursuant to said agreement the sum of Thirteen Thousand Dollars ($13,000) was made available to the State Engineer, to perform approximately half of said specified work, consisting of the sum of Six Thousand Five Hundred Dollars ($6,500) provided by the County and the sum of Six Thousand Five Hundred Dollars ($6,500) provided by the Board; and

WHEREAS, it was the expressed intention in said agreement that at the commencement of the second year of said investigation the County would make available a further sum of Six Thousand Dollars ($6,000) subject to a matching or contribution in equal amount by the Board for the completion of said investigation and report; and

WHEREAS, additional funds are now required to complete said investigation and report, and it is the desire of the parties hereto that an additional sum of Twelve Thousand Dollars ($12,000) shall be provided, Six Thousand Dollars ($6,000) by the County, and Six Thousand Dollars ($6,000) by the Board;

NOW THEREFORE, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the County, and the State Engineer do hereby mutually agree as follows:

1. The County, upon execution by it of this agreement, shall transmit to the State Engineer the sum of Six Thousand Dollars ($6,000) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental.

2. Upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of Six Thousand Dollars ($6,000) from funds appropriated to the Board by Item 259 of the Budget Act of 1949 for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental, and the State Controller will be requested to make such transfer.

3. The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for in said prior agreement to which this agreement is supplemental any amount in excess of the sum of Twenty Five Thousand Dollars ($25,000) as made available under said prior agreement and this supplemental agreement and if funds are exhausted before completion of said work the Board and the State Engineer may discontinue said work and shall not be liable or responsible for the completion thereof.

4. In so far as consistent herewith and to the extent adaptable hereto, all of the terms and provisions of said prior agreement to which this agreement is supplemental are hereby made applicable to this agreement and are hereby confirmed, ratified, and continued in effect.

IN WITNESS WHEREOF, the parties hereunto have affixed their signatures, the County on the 14th day of November, 1949, the Board on the 1st day of December, 1949, and the State Engineer on the 6th day of December, 1949.

Approved as to form:

/s/ Frederick L. Felton
County Counsel
County of San Joaquin

Approval Recommended:

/s/ Henry Holsinger
Principal Attorney
Division of Water Resources

Approval Recommended:

/s/ C. R. Montgomery
Chief Attorney
Department of Public Works

Approved:

Director of Finance

COUNTY OF SAN JOAQUIN

By /s/ W. R. Ruggles
Chairman, Board of Supervisors

/s/ I. M. Golding
Clerk, Board of Supervisors

STATE WATER RESOURCES BOARD

By /s/ C. A. Griffith
Chairman

DEPARTMENT OF PUBLIC WORKS
STATE OF CALIFORNIA

C. H. Purcell
Director of Public Works

[SEAL]

By /s/ Frank B. Durkee
Deputy Director

/s/ Edward Hyatt
Edward Hyatt
State Engineer

E. J. R. Form	F. J. M. Budget	Value	Descript.

Department of Finance
APPROVED
Dec 19 1949
James S. Dean, Director
Original signed by
Louis J. Heinzer
Administrative Adviser

AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE COUNTY OF SAN JOAQUIN AND THE DEPARTMENT OF PUBLIC WORKS

This Agreement, executed in quadruplicate, entered into as of December 1, 1949, by the State Water Resources Board, hereinafter referred to as the "Board"; the County of San Joaquin, hereinafter referred to as the "County"; and the Department of Public Works, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer":

WITNESSETH:

Whereas, by The State Water Resources Act of 1945, as amended, the Board is authorized to make investigations, studies, surveys, prepare plans and estimates, and make recommendations to the Legislature in regard to water development projects; and

Whereas, by said act, the State Engineer is authorized to cooperate with any county, city, State agency or public district on flood control and other water problems and when requested by any thereof may enter into a cooperative agreement to expend money in behalf of any thereof to accomplish the purposes of said act; and

Whereas, the County desires and hereby requests the Board to enter into a cooperative agreement for the making of an investigation and report on the ground water resources in the Farmington-Collegeville area, bounded approximately by the county line on the east side of San Joaquin County on the east, the French Camp Road on the west, the north boundary of the Oakdale and South San Joaquin irrigation districts on the south, and the south boundary of the Stockton and East San Joaquin Water Conservation District on the north, in the County of San Joaquin, including location, replenishment, quality and utilization thereof, and, if possible, a method or methods of solving the water problems involved;

Now Therefore, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the

County, and the State Engineer do hereby mutually agree as follows:

ARTICLE I—WORK TO BE PERFORMED:

The work to be performed under this agreement shall consist of an investigation and report on the ground water supply in said Farmington-Collegeville area, in the County of San Joaquin, including location, replenishment, quality, and utilization thereof, and, if possible, a method or methods of solving the water problems involved.

The Board by this agreement authorizes and directs the State Engineer to cooperate by making said investigation and report and by otherwise advising and assisting in making an evaluation of present and ultimate ground water problems in said Farmington-Collegeville area, and in formulating a possible solution of the water problems thereof.

During the progress of said investigation and report all maps, plans, information, data and records pertaining thereto which are in the possession of any party hereto shall be made fully available to any other party for the due and proper accomplishment of the purposes and objects hereof.

The work under this agreement shall be diligently prosecuted with the objective of completion of the investigation and report on or before December 31, 1951, or as nearly thereafter as possible.

ARTICLE II—FUNDS:

The County, upon execution by it of this agreement, shall transmit to the State Engineer the sum of Four Thousand Five Hundred Dollars ($4,500) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement. Also, upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of Four Thousand Five Hundred Dollars ($4,500) from funds made available to the Board by Item 259 of the Budget Act of 1949, as augmented, for expediture by the State Engineer in performance of the work provided for in this agreement and the State Controller will be requested to make such transfer.

If the Director of Finance, within thirty (30) days after receipt by the State Engineer of said Four Thousand Five Hundred Dollars ($4,500) from the County, shall not have approved the deposit thereof into said Water Resources Revolving Fund, together with the transfer of the sum of said Four Thousand Five Hundred Dollars ($4,500) from funds made available to the Board, for expenditure by the State Engineer in performance of the work provided for in this agreement, such sum contributed by the County shall be returned thereto by the State Engineer.

It is understood by and between the parties hereto that the sum of Nine Thousand Dollars ($9,000) to be made available as hereinbefore provided is adequate to perform approximately forty per cent of the above specified work and it is the understanding that either the County or an appropriate local agency will make a further sum of Seven Thousand Dollars ($7,000) available at the commencement of the second year of said investigation which will be subject to a matching or contribution in an equal sum by the Board for the completion of said investigation and report.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the sum of Nine Thousand Dollars ($9,000) as made available hereunder and when said sum is exhausted, the Board and the State Engineer may discontinue the work provided for in this agreement and shall not be liable or responsible for the resumption and completion thereof until further sums as specified in the preceding paragraph are made available.

Upon completion of and final payment for the work provided for in this agreement, the State Engineer shall furnish to the Board and to the County a statement of all expenditures made under this agreement. One-half of the total amount of all said expenditures shall be deducted from the sum advanced from funds appropriated to said Board, and one-half of the total amount of all said expenditures shall be deducted from the sum advanced by the County and any balance which may remain shall be returned to the Board, and to the County, in equal amount.

In Witness Whereof, the parties hereto have executed this agreement to be effective as of the date hereinabove first written.

Approved as to Form:

/s/ FREDERICK L. FELTON
County Counsel
County of San Joaquin

Approval Recommended:

/s/ HENRY HOLSINGER
Principal Attorney
Division of Water Resources

Approved as to Legality:

/s/ C. R. MONTGOMERY
Chief Attorney
Department of Public Works

Approved:

____
Director of Finance

COUNTY OF SAN JOAQUIN

By /s/ W. R. RUGGLES [SEAL]
Chairman, Board of Supervisors

/s/ R. E. GRAHAM
Clerk, Board of Supervisors

STATE WATER RESOURCES BOARD

By /s/ C. A. GRIFFITH
Chairman

DEPARTMENT OF PUBLIC WORKS
STATE OF CALIFORNIA

C. H. PURCELL [SEAL]
By /s/ FRANK B. DURKEE
Deputy Director of Public Works

/s/ EDWARD HYATT
Edward Hyatt
State Engineer

E.J.R. Form	F.J.M. Budget	Value	Descript.

DEPARTMENT OF FINANCE
APPROVED
Jan 19 1950

JAMES S. DEAN, Director
By LOUIS J. HEINZER
Administrative Adviser

SUPPLEMENTAL AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE COUNTY OF SAN JOAQUIN, AND THE DEPARTMENT OF PUBLIC WORKS

THIS AGREEMENT, executed in quintuplicate, entered into as of December 1, 1950, by the State Water Resources Board, hereinafter referred to as the "Board"; the County of San Joaquin, hereinafter referred to as the "County"; and the Department of Public Works of the State of California, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer."

WITNESSETH:

WHEREAS, by agreement heretofore entered into as of December 1, 1949, by and between the County, the Board, and the State Engineer, it was provided that the work to be performed thereunder shall consist of the making by the State Engineer of an investigation and report on the ground water resources in the Farmington-Collegeville area, bounded approximately by the county line on the east side of San Joaquin County on the east, the French Camp Road on the west, the north boundary of the Oakdale and South San Joaquin irrigation districts on the south, and the south boundary of the Stockton and East San Joaquin Water Conservation District on the north, in the County of San Joaquin, including location, replenishment, quality and utilization thereof, and, if possible, a method or methods of solving the water problems involved; and

WHEREAS, under said agreement the County made available the sum of Four Thousand Five Hundred Dollars ($4,500) which was matched in an equal amount by the Board for expenditure by the State Engineer in the performance of the work provided for in said agreement; and

WHEREAS, it was the expressed intention in said agreement that at the commencement of the second year of said investigation the County or an appropriate local agency, would make available a further sum of Seven Thousand Dollars ($7,000) subject to a matching or contribution in an equal sum by the Board for the completion of said investigation and report; and

WHEREAS, the funds provided for under said prior agreement, to which this agreement is supplemental, have been exhausted and additional funds are now required to complete said investigation and report, and it is the desire of the parties hereto that an additional sum of Fourteen Thousand Dollars ($14,000) shall be provided, Seven Thousand Dollars ($7,000) by the County and Seven Thousand Dollars ($7,000) by the Board;

Now Therefore, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the County, and the State Engineer do hereby mutually agree as follows:

1. The County, upon execution by it of this agreement, shall transmit to the State Engineer the sum of Seven Thousand Dollars ($7,000) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental.

2. Upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of Seven Thousand Dollars ($7,000) from funds appropriated to the Board by Item 257 of the Budget Act of 1950 for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental, and the State Controller will be requested to make such transfer.

3. The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for in said prior agreement to which this agreement is supplemental any amount in excess of the sum of Twenty-Three Thousand Dollars ($23,000) as made available under said prior agreement and this supplemental agreement and if funds are exhausted before completion of said work the Board and the State Engineer may discontinue said work and shall not be liable or responsible for the completion thereof.

4. In so far as consistent herewith and to the extent adaptable hereto, all of the terms and provisions of said prior agreement to which this agreement is supplemental are hereby made applicable to this agreement and are hereby confirmed, ratified, and continued in effect.

In Witness Whereof, the parties hereto have executed this agreement to be effective as of the date hereinabove first written.

Approved as to form:

/s/ Frederick L. Felton
County Counsel
County of San Joaquin

Approval Recommended:

/s/ Henry Holsinger
Principal Attorney
Division of Water Resources

Approval Recommended:

/s/ Robert E. Reed
Attorney,
Department of Public Works

Approved:

____
Director of Finance

COUNTY OF SAN JOAQUIN

By /s/ George Ohm
Chairman, Board of Supervisors

[SEAL]

/s/ R. E. Graham
Clerk, Board of Supervisors

STATE WATER RESOURCES BOARD

By /s/ C. A. Griffith
Chairman

DEPARTMENT OF PUBLIC WORKS
STATE OF CALIFORNIA

C. H. Purcell
Director of Public Works

[SEAL]

By /s/ Frank B. Durkee
Deputy Director

/s/ A. D. Edmonston
A. D. Edmonston
State Engineer

L.N.G. Form	J.S.R. Budget	VALUE	DESCRIPT.

DEPARTMENT OF FINANCE
APPROVED
Mar 8 1951

James S. Dean, Director
By /s/ Louis J. Heinzer
Administrative Adviser

SUPPLEMENTAL AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE COUNTY OF SAN JOAQUIN, AND THE DEPARTMENT OF PUBLIC WORKS

This Agreement, executed in quintuplicate, entered nto as of June 1, 1952, by the State Water Resources Board, hereinafter referred to as the "Board"; the County of San Joaquin, hereinafter referred to as the "County"; and the Department of Public Works of he State of California, acting through the agency of he State Engineer, hereinafter referred to as the 'State Engineer":

WITNESSETH:

Whereas, an investigation of the Farmington-Collegeville Area in San Joaquin County has been conducted by the Department of Public Works, acting by nd through the agency of the State Engineer, beween December 1949 and May 1952, and a report on he results of said investigation is being prepared puruant to a cooperative arrangement between the Deartment and the County of San Joaquin whereby the vork accomplished, including the preparation of a eport, was financed with funds contributed equally y the County of San Joaquin and the State of Caliornia; and

Whereas, funds were appropriated to the Board y Item 269 of the Budget Act of 1952 for continuing vork on ground water level and stream flow measurenents, a quality of water check, and collection of crop urvey records in the Farmington-Collegeville Area n a matching basis pending accomplishment of soluion of the water problems in that area; and

Whereas, by The State Water Resources Act of 945, as amended, the Board is authorized to make nvestigations, studies, surveys, prepare plans and stimates, and make recommendations to the Legislaure in regard to water development projects; and

Whereas, by said act, the State Engineer is authorzed to cooperate with any county, city, State Agency r public district on flood control and other water roblems and when requested by any thereof may nter into a cooperative agreement to expend money n behalf of any thereof to accomplish the purpose of aid act; and

Whereas, the County desires and hereby requests he Board to enter into a cooperative agreement or the making of ground water level and stream ow measurements, a quality of water check, and crop urveys in the Farmington-Collegeville Area between une 1, 1952 and June 1, 1953.

Now Therefore, in consideration of the premses and of the several promises to be faithfully perormed by each as hereinafter set forth, the Board, e County, and the State Engineer do hereby muually agree as follows:

ARTICLE I—WORK TO BE PERFORMED

The work to be performed under this agreement may include a series of ground water level measurements in the fall of 1952 and the spring of 1953, stream flow measurements from time to time, collection and analysis of samples of surface and ground waters, collection of crop survey records and compilation of results of such measurements, analysis and other data, and operation and maintenance of the stream gaging stations on Lone Tree Creek at Valley Home, Lone Tree Creek at Austin Road, Tempo Creek at Jack Tone Road, French Camp Slough at Sharp's Lane, Duck Creek at Farmington, and Duck Creek at Mariposa Road.

The Board by this agreement authorizes and directs the State Engineer to cooperate in performing said work and compiling the results thereof.

During the progress of said investigation all maps, plans, information, data, and records pertaining thereto which are in the possession of any party hereto shall be made fully available to any other party for the due and proper accomplishment of the purposes and objects hereof.

The work under this agreement shall be diligently prosecuted with the objective of completion of the investigation and compilation of data by June 1, 1953, or as nearly thereafter as possible.

ARTICLE II—FUNDS

The County, upon execution by it of this agreement, shall transmit to the State Engineer the sum of One Thousand Dollars ($1,000) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditures by the State Engineer in performance of the work provided for in this agreement. Also, upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of One Thousand Dollars ($1,000) from funds made available to the Board by Item 269 of the Budget Act of 1952, as augmented, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement and the State Controller will be requested to make such transfer.

If the Director of Finance, within thirty (30) days after receipt by the State Engineer of said One Thousand Dollars ($1,000) from the County, shall not have approved the deposit thereof into said Water Resources Revolving Fund, together with the sum of said One Thousand Dollars ($1,000) transferred from funds made available to the Board, for expenditure by the State Engineer in performance of the work provided for in this agreement, such sum contributed by the County shall be returned thereto by the State Engineer.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the sum of Two Thousand Dollars ($2,000) as made available hereunder and when said sum is exhausted, the Board and the State Engineer may discontinue the work provided for in this agreement and shall not be liable or responsible for the resumption and completion thereof.

Upon completion of and final payment for the work provided for in this agreement, the State Engineer shall furnish to the Board and to the County a statement of all expenditures made under this agreement. One-half of the total amount of all said expenditures shall be deducted from the sum advanced from funds appropriated to said Board, and one-half of the total amount of all said expenditures shall be deducted from the sum advanced by the County and any balance which may remain shall be returned to the Board, and to the County, in equal amount.

In Witness Whereof, the parties hereto have executed this agreement to be effective as of the date hereinabove first written.

Approved as to Form and Procedure

/s/ F. L. Felton
County Counsel
County of San Joaquin

Approved as to Form and Procedure

/s/ Mark C. Nosler
Attorney for Division of
Water Resources

Approved as to Form and Procedure

____

Attorney, Department of Public Works

Approved:

____

Director of Finance

COUNTY OF SAN JOAQUIN

By /s/ George Ohm
Chairman, Board of Supervisors

STATE WATER RESOURCES BOARD

By /s/ C. A. Griffith
Chairman

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS

Frank B. Durkee
Director of Public Works

[SEAL]

By /s/ Russell S. Munro
Russell S. Munro
Acting Deputy Director of Public Works

/s/ A. D. Edmonston
A. D. Edmonston
State Engineer

L. E. Z. Form	F. J. M. Budget	Value	Descript.

DEPARTMENT OF FINANCE
APPROVED
JUL 14 1952
James S. Dean, Director
Original signed by
Louis J. Heinzer
Administrative Adviser

AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE NORTH SAN JOAQUIN WATER CONSERVATION DISTRICT, AND THE DEPARTMENT OF PUBLIC WORKS

This Agreement, executed in quintuplicate, entered into as of November 1, 1951, by the State Water Resources Board, hereinafter referred to as the "Board"; the North San Joaquin Water Conservation District, hereinafter referred to as the "District"; and the Department of Public Works of the State of California, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer":

WITNESSETH:

Whereas, an investigation of the Mokelumne River Area in San Joaquin County has been conducted by the Department of Public Works, acting by and through the agency of the State Engineer, between December 1948 and October 1951, and a report on the results of said investigation is being prepared pursuant to a cooperative arrangement between the Department and the County of San Joaquin whereby the work accomplished, including the preparation of a report, was financed with funds contributed equally by the County of San Joaquin and the State of California; and

Whereas, funds were appropriated to the Board by Item 251 of the Budget Act of 1951 for continuing work on ground water level and stream flow measurements, a quality of water check, and collection of crop survey records in the Mokelumne River Area on a matching basis pending accomplishment of solution of the water problems in that area; and

Whereas, by The State Water Resources Act of 1945, as amended, the Board is authorized to make investigations, studies, surveys, prepare plans and estimates, and make recommendations to the Legislature in regard to water development projects; and

Whereas, by said act, the State Engineer is authorized to cooperate with any county, city, State agency or public district on flood control and other water problems and when requested by any thereof may enter into a cooperative agreement to expend money in behalf of any thereof to accomplish the purposes of said act; and

Whereas, the District desires and hereby requests the Board to enter into a cooperative agreement for the making of ground water level and stream flow measurements, a quality of water check, and crop surveys in the Mokelumne River Area between November 1, 1951 and December 31, 1952.

Now Therefore, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the District, and the State Engineer do hereby mutually agree as follows:

ARTICLE I—WORK TO BE PERFORMED

The work to be performed under this agreement may include a series of ground water level measurements in the spring and fall of 1952, stream flow measurements from time to time, collection and analysis of samples of surface and ground waters, collection of crop survey records and compilation of results of such measurements, analysis and other data, operation and maintenance of the stream gaging station on the Mokelumne River at Clements.

The Board by this agreement authorizes and directs the State Engineer to cooperate in performing said work and compiling the results thereof.

During the progress of said investigation and report all maps, plans, information, data and records pertaining thereto which are in the possession of any party hereto shall be made fully available to any other party for the due and proper accomplishment of the purposes and objects hereof.

The work under this agreement shall be diligently prosecuted with the objective of completion of the investigation and compilation of data by December 31, 1952, or as nearly thereafter as possible.

ARTICLE II—FUNDS:

The District, upon execution by it of this agreement, shall transmit to the State Engineer the sum of One Thousand Dollars ($1,000) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditures by the State Engineer in performance of the work provided for in this agreement. Also, upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of One Thousand Dollars ($1,000) from funds made available to the Board by Item 251 of the Budget Act of 1951, as augmented, for expenditure by the State Engineer in performance of the work provided for in this agreement and the State Controller will be requested to make such transfer.

If the Director of Finance, within thirty (30) days after receipt by the State Engineer of said One Thousand Dollars ($1,000) from the District, shall not have approved the deposit thereof into said Water Resources Revolving Fund, together with the transfer of the sum of said One Thousand Dollars ($1,000) from funds made available to the Board, for expenditure by the State Engineer in performance of the work provided for in this agreement, such sum contributed by the District shall be returned thereto by the State Engineer.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the sum of Two Thousand Dollars ($2,000) as made available hereunder and when said sum is exhausted, the Board and the State Engineer may discontinue the work provided for in this agreement and shall not be liable or responsible for the resumption and completion thereof.

Upon completion of and final payment for the work provided for in this agreement, the State Engineer shall furnish to the Board and to the District a statement of all expenditures made under this agreement. One-half of the total amount of all said expenditures shall be deducted from the sum advanced from funds appropriated to said Board, and one-half of the total amount of all said expenditures shall be deducted from the sum advanced by the District and any balance which may remain shall be returned to the Board and to the District, in equal amount.

In Witness Whereof, the parties hereto have executed this agreement to be effective as of the date hereinabove first written.

Approved as to Form:

/s/ R. P. Rott
Attorney for North
San Joaquin Water Conservation
District

Approved as to form and procedure

/s/ Henry Holsinger
Attorney for Division of Water Resources

Approved as to form and procedure

____
Attorney, Department of Public Works

Approved:

/s/ James S. Dean
Director of Finance

NORTH SAN JOAQUIN WATER
CONSERVATION DISTRICT

By /s/ Louis Hieb
Chairman, Board of Directors

STATE WATER RESOURCES BOARD

By /s/ C. A. Griffith
Chairman

[SEAL]

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS

/s/ Frank B. Durkee
Frank B. Durkee
Director of Public Works

By

____

/s/ A. D. Edmonston
A. D. Edmonston
State Engineer

L. E. S. Form	F. J. M. Budget	Value	Descript.

DEPARTMENT OF FINANCE
APPROVED
NOV 8 1951

AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE STOCKTON-EAST SAN JOAQUIN WATER CONSERVATION DISTRICT, AND THE DEPARTMENT OF PUBLIC WORKS

This Agreement, executed in quintuplicate, en-ered into as of May 1, 1952, by the State Water lesources Board, hereinafter referred to as the Board"; the Stockton-East San Joaquin Water onservation District, hereinafter referred to as the District"; and the Department of Public Works of e State of California, acting through the agency of e State Engineer, hereinafter referred to as the State Engineer":

WITNESSETH:

Whereas, an investigation of the Calaveras River rea in San Joaquin County has been conducted by e Department of Public Works, acting by and rough the agency of the State Engineer, between ebruary 1948 and April 1952, and a report on the esults of said investigation is being prepared pur-uant to a cooperative arrangement between the De-artment and the County of San Joaquin whereby the ork accomplished, including the preparation of a eport, was financed with funds contributed equally y the County of San Joaquin and the State of Cali-ornia; and

Whereas, funds were appropriated to the Board by em 269 of the Budget Act of 1952 for continuing ork on ground level and stream flow measurements, quality of water check, and collection of crop survey ecords in the Calaveras River Area on a matching asis pending accomplishment of solution of water roblems in that area; and

Whereas, by The State Water Resources Act of 945, as amended, the Board is authorized to make ivestigations, studies, surveys, prepare plans and stimates, and make recommendations to the Legisla-ure in regard to water development projects; and

Whereas, by said act, the State Engineer is author-ed to cooperate with any county, city, State agency public district on flood control and other water roblems and when requested by any thereof may nter into a cooperative agreement to expend money behalf of any thereof to accomplish the purposes said act; and

Whereas, the District desires and hereby requests e Board to enter into a cooperative agreement for e making of ground water level and stream flow easurements, a quality of water check, and crop sur-ys in the Calaveras River Area between May 1, 1952 d May 1, 1953.

Now Therefore, in consideration of the premises d of the several promises to be faithfully performed each as hereinafter set forth, the Board, the Dis-ict, and the State Engineer do hereby mutually gree as follows:

ARTICLE I—WORK TO BE PERFORMED

The work to be performed under this agreement may include a series of ground water level measurements in the fall of 1952 and the spring of 1953, stream flow measurements from time to time, collection and analysis of samples of surface and ground waters, collection of crop survey records and compilation of results of such measurements, analysis and other data, operation and maintenance of the stream gaging stations on the Calaveras River at Bellota, Calaveras River at Solari Road, and Mormon Slough at Bellota.

The Board by this agreement authorizes and directs the State Engineer to cooperate in performing said work and compiling the results thereof.

During the progress of said investigation and report all maps, plans, information, data and records pertaining thereto which are in the possession of any party hereto shall be made fully available to any other party for the due and proper accomplishment of the purposes and objects hereof.

The work under this agreement shall be diligently prosecuted with the objective of completion of the investigation and compilation of data by May 1, 1953, or as nearly thereafter as possible.

ARTICLE II—FUNDS:

The District, upon execution by it of this agreement, shall transmit to the State Engineer the sum of One Thousand Dollars ($1,000) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditures by the State Engineer in performance of the work provided for in this agreement. Also, upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of One Thousand Dollars ($1,000) from funds made available to the Board by Item 269 of the Budget Act of 1952, as augmented, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement and the State Controller will be requested to make such transfer.

If the Director of Finance, within thirty (30) days after receipt by the State Engineer of said One Thousand Dollars ($1,000) from the District, shall not have approved the deposit thereof into said Water Resources Revolving Fund, together with the sum of said One Thousand Dollars ($1,000) transferred from funds made available to the Board, for expenditure by the State Engineer in performance of the work provided for in this agreement, such sum con-

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tributed by the District shall be returned thereto by the State Engineer.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the sum of Two Thousand Dollars ($2,000) as made available hereunder and when said sum is exhausted, the Board and the State Engineer may discontinue the work provided for in this agreement and shall not be liable or responsible for the resumption and completion thereof.

Upon completion of and final payment for the work provided for in this agreement, the State Engineer shall furnish to the Board and to the District a statement of all expenditures made under this agreement. One-half of the total amount of all said expenditures shall be deducted from the sum advanced from funds appropriated to said Board, and one-half of the total amount of all said expenditures shall be deducted from the sum advanced by the District and any balance which may remain shall be returned to the Board, and to the District, in equal amount.

In Witness Whereof, the parties hereto have executed this agreement to be effective as of the date hereinabove first written.

Approved as to Form and Procedure

/s/ Irving B. Neumiller
Attorney for Stockton-East San Joaquin Water Conservation District

Approved as to Form and Procedure

/s/ Henry Holsinger
Attorney for Division of Water Resources

Approved as to Form and Procedure

Attorney, Department of Public Works

Approved:

/s/ James S. Dean
Director of Finance

By A. Earl Washburn
Deputy Director of Finance

STOCKTON-EAST SAN JOAQUIN WATER CONSERVATION DISTRICT

By /s/ Francis Grupe
Chairman, Board of Directors

STATE WATER RESOURCES BOARD

By /s/ C. A. Griffith
Chairman

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS [seal]

Frank B. Durkee
Director of Public Works

By /s/ Russell S. Munro
Russell S. Munro
Acting Deputy Director of Public Works

/s/ A. D. Edmonston
A. D. Edmonston
State Engineer

LKD	LFH
Form	Budget

Department of Finance
APPROVED
JUL 28 1952

APPENDIX B

COMMENTS BY CONCERNED AGENCIES ON BULLETIN NO. 11, "SAN JOAQUIN COUNTY INVESTIGATION"

TABLE OF CONTENTS

COMMENTS BY CONCERNED AGENCIES ON BULLETIN NO. 11, "SAN JOAQUIN COUNTY INVESTIGATION"

AMADOR COUNTY

Board of Supervisors
Jackson, California, October 31, 1955

State Water Resources Board,
1120 N Street, Sacramento, California
Subject: Bulletin No. 11

Gentlemen: We greatly appreciate the work of the State Water Resources Board in coordinating the needs of the various water users along the North Fork of the Mokelumne River, as outlined in preliminary draft of Bulletin No. 11.

The Board of Supervisors of Amador County at this time wish to bring to the attention of the State Water Resources Board the fact that an active project is under way to bring water to the villages of Volcano, Pioneer and Pine Grove by exercising the water rights involved in water right application No. 13034. Storage dams on Antelope Creek and Mill Creek with diversion from Tiger Creek and Panther Creek are now in process of survey and completion of the application during November is expected.

Yours very truly,

Earl J. Garbarini
Board of Supervisors of
Amador County

CALAVERAS COUNTY WATER DISTRICT

SAN ANDREAS, CALIFORNIA

Sacramento 14, California
October 31, 1955

State Water Resources Board,
Public Works Building, Sacramento 5, California

Subject: Comments on SWRB Bulletin No. 11

Gentlemen: In response to your invitation to comment on this bulletin, for inclusion in the final publication, I am at the instance of the Board of Directors of Calaveras County Water District, attaching a "Summary of the Calaveras County Water District's Proposed Project for the Development of the North Fork of the Stanislaus River" prepared by the District's engineer, which proposal bears upon the subject of the report.

Very truly yours,

Vernon Campbell
President

SUMMARY OF THE CALAVERAS COUNTY WATER DISTRICT'S PROPOSED PROJECT FOR THE DEVELOPMENT OF THE NORTH FORK OF THE STANISLAUS RIVER

In order to coordinate the development of the waters of the North Fork of the Stanislaus River with the proposed development of the South and Middle Forks of the Mokelumne River and certain tributary streams of the Calaveras River for the complete service of the lands and urban areas in Calaveras County, the district proposes the following project for the North Fork of the Stanislaus River:

An enlarged dam at the site of the present Spicer Dam and Reservoir will be constructed to give a storage capacity of 45,000 acre-feet; the elevation at this dam will be approximately 6,368 feet. It is also proposed to construct a dam at the so-called Gann's site to create a storage reservoir at an elevation of 5,465 feet which will create a reservoir of 47,000 acre-feet.

The waters from the storages at Spicer and Gann's Reservoirs commingled with the natural flow of the stream will be taken into a 5.9 mile conduit at the Gann's dam site and conveyed to the forebay of the Ramsay power house at an elevation of 5,520 feet and thence conveyed to the power house at the backwaters of Ramsay Reservoir at elevation 4,740 feet. It is estimated that this plant will have a generating capacity of 15,000 kw. It is proposed to construct a dam at the Ramsay site at elevation 4,535 and to have a storage capacity of 32,000 acre-feet.

From the Ramsay damsite the natural flow of the river will be commingled with the stored waters from the three above-described reservoirs and conveyed in a conduit approximately eight miles in length to the forebay of a power house to be known as the Calaveras Power House, at an approximate elevation of 4,500 feet. This power plant will have a generating capacity of 20,000 kw. On this conduit at elevation approximately 4,515 feet near the center of S. 13, T. 5 N., R. 15 E., M. D. B. & M. there will be provided a diversion works and tunnel entrance for use in conveying water to the headwaters of San Antone Creek from whence waters can be distributed across the headwaters of Calaveritas Creek, Jesus Maria Creek, Esperanza Creek and the North Fork of the Calaveras

River for irrigation and other uses in central Calaveras County.

From the afterbay of the Calaveras Power House the waters will be diverted through a tunnel 4.9 miles long to Moran Creek near Avery at an elevation of approximately 3,400 feet and taken thence by conduit along the northerly side of San Domingo Creek to the forebay of a power house located at elevation 3,380 on San Domingo Creek. The installed generating capacity will be 30,000 kw.

From this point the waters may be turned into San Domingo Creek and conveyed to the Hogan Reservoir for storage and reregulation for use in west and northwest Calaveras County. The water will be taken at the tailrace at the Avery Power House and conveyed approximately four miles to the forebay of another power house located at elevation 2,475 where the installed capacity will be 20,000 kw. This power house will be located at the backwater of the San Domingo Reservoir. San Domingo Dam to create San Domingo Reservoir with a capacity of 38,000 acre-feet will be located at elevation 1,705 on San Domingo Creek.

At this point the conversion from a purely power schedule to an irrigation schedule will commence. An irrigation conduit will be constructed from San Domingo Reservoir southwesterly to the top of Brunner Hill near Altaville and thence westerly to and across the ridge near Copperopolis where the waters so conveyed will be passed through another power house located at elevation 1,650 near the townsite of Copperopolis with an installed generating capacity of 10,000 kw. The water from this power house will be conveyed to Salt Springs Valley Reservoir which will be enlarged to a total capacity of 75,000 acre-feet and from there waters will be used for irrigation and incidental domestic purposes in the western portion of Calaveras County, the eastern portion of San Joaquin, and the northeast portion of Stanislaus County.

FRANK DAVIS

EAST BAY MUNICIPAL UTILITY DISTRICT

OAKLAND 23, CALIFORNIA, November 8, 1955

STATE WATER RESOURCES BOARD
Public Works Building, Sacramento 5, California
Attention Mr. Harvey O. Banks,
Acting State Engineer, Secretary

GENTLEMEN:

Enclosed herewith is a review by East Bay Municipal Utility District of Bulletin No. 11, "San Joaquin County Investigation," as amended by the major corrections and revisions made on September 15, 1955.

The enclosure is transmitted to you in accordance with the suggestions which have previously been made by Mr. Edmonston and his staff members.

It is regretted that the time element has been so complicated that we have been delayed in transmitting this document to you.

Your courtesy in expressing a wish for our comments is greatly appreciated.

Yours very truly,

JOHN W. MCFARLAND
General Manager

COMMENTS BY EAST BAY MUNICIPAL UTILITY DISTRICT ON BULLETIN NO. 11 "SAN JOAQUIN COUNTY INVESTIGATION"

A Publication of the State Water Resources Board, As Amended on September 15, 1955, By "Major Corrections and Revisions in Preliminary Draft of Bulletin No. 11, 'San Joaquin County Investigation,' Dated April, 1954," November, 1955

GENERAL STATEMENT

This review of Bulletin No. 11 is presented by the East Bay Municipal Utility District pursuant to the suggestion of the Secretary of the State Water Resources Board. It deals with matters affecting water use and development on the Mokelumne River.

The East Bay Municipal Utility District is a public agency, operated under the laws of the State of California, and governed by an elective board of directors. It was created by a vote of the people on May 8, 1923, in accordance with the Municipal Utility District Act of 1921, for the purpose of providing a water supply that would take care of existing and future requirements of the East Bay area. The Mokelumne project, constructed in the four years 1925 to 1929 at a cost of $39,000,000, brought water from the Mokelumne River to the East Bay area in June of the latter year, narrowly averting a serious water shortage. Originally comprising an area of 93 square miles, the district has expanded by annexation of adjacent territory to an area of 213 square miles at the present time. It includes the Cities of Oakland, Berkeley, Alameda, San Leandro, Albany, Piedmont and Emeryville in Alameda County; Richmond, El Cerrito, San Pablo, Walnut Creek, Pinole and Hercules in Contra Costa County; and unincorporated communities in both counties. The 1955 population is estimated at 992,000. Daily water consumption for the Fiscal Year 1954-55 averaged 122,000,000 gallons. To meet the growing demand, the district in 1949 constructed the Second

Mokelumne Aqueduct at a cost of more than $21,000,-000. The two aqueducts now in operation are capable, when certain additional pumping capacity is added, of bringing to the East Bay area the full amount of 200,000,000 gallons daily, the capacity for which the project was originally designed and for which permit was issued by the State in 1926. This supply is expected to meet demands for only a limited number of years. To supply the future water needs of this growing area, the district plans a further development of its present source on the Mokelumne River, in accordance with its pending Application No. 13156, filed with the State Engineer in 1949.

The study reported in Bulletin No. 11 finds that the probable ultimate annual supplemental water requirement of the eastern and western Mokelumne units is a very substantial quantity, greater than the total new irrigation supply which could be developed for that purpose on the Mokelumne River, by construction of the Camanche, Middle Bar and Railroad Flat projects. It shows that water from either the Folsom project or the Delta diversion project must eventually be imported for use in the Mokelumne units if that area is to realize the potential growth and development of which it is capable, and that these two projects are the only ones big enough to do the whole job. Furthermore, it is shown that irrigation water from these projects can be supplied at less expense than any supply obtained from the Mokelumne River projects. These findings are the major results of the bulletin relating to development of the Mokelumne River, and the utility district, from prior and independent studies made by its engineering staff, concurs in each of them.

The bulletin states:

> Results of the State-wide Water Resources Investigation to date indicate that if California is to attain growth and development commensurate with her manifold resources, nearly all of the potential reservoir storage capacity of the State must be constructed and dedicated to operation for water conservation purposes.

The district likewise concurs in this statement, which is in close accord with the position of the district on development of the Mokelumne River, as expressed in its Application No. 13156 now pending before the Division of Water Resources.

There is thus a basic agreement on major issues. With respect to certain other matters presented in the bulletin, it appears that the data and conclusions therein are not entirely in agreement with information available to the district or with conclusions which the district has reached as a result of its studies. Accordingly, the viewpoint of the district on these issues is presented in subsequent parts of this statement. However, in many instances where agreement is lacking, the differences are of a technical nature or are considered minor in the sense that they do not necessarily affect water development, and in such instances, comments are withheld.

SAN JOAQUIN WATER SUPPLY AND UTILIZATION

In the discussion of "Present Supplemental Water Requirement," the assumption is made that the present maximum monthly rate of diversion from the Mokelumne River by the Woodbridge Irrigation District, was 450 second-feet in July. However, evidence is lacking to show that this rate of diversion is a beneficial use. The acreage irrigated and observations of canal wastage indicate that such a large quantity of diversion is not beneficially used by the Woodbridge Irrigation District. Accordingly, it appears that the assumed rate of diversion, and the resulting determination of available supply in normal and wet years, are both too large.

The same comments apply to the assumption of a full seasonal demand of 149,000 acre-feet for use by the Woodbridge Irrigation District. Evidence is lacking to show that this supply is or could be beneficially used. The irrigation efficiency of the irrigation district's system, measured by the ratio of consumptive use of surface water to gross headgate diversion, is indicated in the following tabulation:

WOODBRIDGE IRRIGATION DISTRICT
IRRIGATION EFFICIENCY
1939 - 1951

Irrigation season	*Diversion acre-feet*	*Acres irrigated*	*Gross duty, feet*	*Consumptive use of surface water ** *Acre-feet*	*Consumptive use of surface water ** *Feet*	*Irrigation efficiency percent*
1939	99,920	12,784	7.8	24,990	2.0	25
1940	90,470	13,217	6.8	28,360	2.1	31
1941	94,780	14,807	6.4	30,960	2.1	33
1942	93,840	13,512	6.9	28,220	2.1	30
1943	103,170	13,165	7.8	28,240	2.1	27
1944	115,530	14,756	7.8	29,100	2.0	25
1945	112,160	14,114	7.9	28,170	2.0	25
1946	128,570	16,081	8.0	31,800	2.0	25
1947	108,460	14,641	7.4	26,300	1.8	24
1948	123,510	13,975	8.8	27,610	2.0	22
1949	130,960	14,548	9.0	29,020	2.0	22
1950	145,880	15,743	9.3	32,820	2.1	23
1951	117,140	16,067	7.3	35,280	2.2	30

* Data from which this tabulation was prepared were taken from Table 33, Bul. No. 11, and Annual Reports of Woodbridge Irrigation District.

The efficiencies are very low and do not meet the standards of reasonable beneficial use. The present 45 percent gross efficiency estimated in the bulletin to be the average for the San Joaquin area, including the Woodbridge area, is considerably better, but still is far from ideal. As pointed out in a subsequent section of the bulletin, it is "considered reasonable to assume that average irrigation efficiencies of 75 percent could be accomplished. * * *"

In the tabulation of diversions from the Mokelumne River for 1948-49 through 1951-52, the diversions by riparian and appropriative divertors below Pardee Reservoir were 11,880; 12,330; 12,780; and 11,150 acre-feet per year respectively, for the four years, according to data and estimates by the Utility District. These figures should replace the amounts of 14,600 acre-feet per year shown in the tabulation as an estimate obtained from the Utility District.

Legal Considerations.

It is noted that in the generally excellent discussion of this topic in the bulletin, no mention is made of the special provisions of the law governing the use of water for domestic and municipal purposes in California. The need for such supplies will, it is believed, have a bearing on the water development dealt with in the bulletin. These provisions referred to are contained in Sections 106.5 and 1460 to 1464 of the Water Code, and should, it is felt, be given consideration commensurate with the effect they may have on water supply development in San Joaquin County and other areas.

Mountain and Foothill Service Areas.

In Chapter IV of the bulletin is a discussion of the use of water in the mountain and foothill service areas designated as the West Point, Mokelumne and Bear Creek service areas. The ultimate water requirement estimated in Bulletin No. 11 for these areas is 112,000 acre-feet per year, presumably on the assumption that these areas would largely be devoted to irrigated agriculture.

Mountain and foothill water supply is of great importance in the effect it may have on plans of the utility district. If the supply of 112,000 acre-feet annually is to be provided from the Mokelumne River for the mountain and foothill areas, as suggested in Bulletin No. 11, it would render totally infeasible the plans of the utility district under its Application 13156, or, in fact, any further development of the Mokelumne River except for the mountain and foothill areas. Data are not presented in the bulletin, however, to indicate whether such use of water in the mountain and foothill areas would be agriculturally or economically feasible.

Since the investigation is still in progress, the utility district believes that it should include a detailed soil survey of the mountain and foothill areas to be served, a study of the agricultural and economic factors involved in the irrigation of these areas, as opposed to the domestic, urban and industrial use of water which prevails there at the present time, and an investigation of supplies available on the Mokelumne River and their cost. In view of the very high cost of the supply which could be developed at the Railroad Flat site it is suggested that consideration be given to the use of water pumped from the Folsom South Canal at least for the foothill service areas.

The phrase "most practicably" is used to describe the supplying of water for the Mokelumne and Bear Creek service areas from the Mokelumne River. This is regarded as inconsistent with the lack of plans and costs for doing so. It would be most impracticable to consider a water cost of $29.70 per acre-foot (Table 66, Railroad Flat project, as contained in the "Major Corrections") to irrigate pasture in the foothill areas. It would be "physically" possible to serve these areas from the Mokelumne River, but the practicability of doing so is doubtful.

It is noted that no mention is made of the possibility that water from the Stanislaus River could be utilized to irrigate the Mokelumne and Bear Creek service areas. Plate 16, on the other hand, shows a diversion from the Stanislaus into McCarty Reservoir site, whence it could readily be distributed to those service areas. It is desirable to determine the status and feasibility of this diversion.

No information is given in the bulletin to show how the Mokelumne River could be developed to satisfy the water requirements in the mountain and foothill areas mentioned. If it were so developed, it appears that large pump lifts from low level reservoirs, together with costly conduits, would be required. In that event, water from the Folsom South Canal would probably be more economical.

East Bay Area

The utility district is now diverting an average of about 180 second-feet from the Mokelumne River and facilities have been provided at a cost of some $60,000,000 which will permit (with the installation of two additional booster plants) the diversion of 310 second-feet under its State Permit No. 2459. An application has been filed with the State which, if approved, will increase the utility district's ultimate diversion to 504 second-feet. The East Bay area, with a present population of 990,000 and an estimated ultimate population of about 2,600,000, is thus dependent upon the Mokelumne River for the major portion of its water supply. This use, present and proposed, is wholly municipal in character.

Careful studies have been made by the utility district as well as by other public agencies, of the probable growth of the East Bay area and its future water requirements. The records show that the water consumption is increasing rapidly and somewhat uniformly at present. The planning studies indicate that the future water requirements can be predicted with reasonable accuracy. There can be little, if any, question as to the reasonableness of the prediction as to the future needs of the East Bay area.

These requirements, present and future, are well known to the State Division of Water Resources, and have been recognized in public reports and in statements of representatives of the division. They will inevitably affect the San Joaquin area problem inasmuch as all of the major facilities for diverting approximately twice the present draft have been built by the utility district in compliance with Water Right Permit No. 2459, with the expectation that they will be fully utilized.

The present and future needs of the utility district should therefore be fully recognized and considered in Bulletin No. 11. This has not been done in Bulletin No. 11 and we hope and assume that it will be done in future publications.

NORTH SAN JOAQUIN WATER CONSERVATION DISTRICT

November 14, 1955

State Water Resources Board
Public Works Building, Sacramento 5, California
Attention: Mr. Harvey O. Banks,
Acting State Engineer, Secretary

Re: Preliminary draft of Bulletin No. 11, dated April 1954, as modified by the September 15, 1955, "Major Corrections in Preliminary Draft of Bulletin No. 11, 'San Joaquin County Investigation,' dated April, 1954."

Gentlemen: The North San Joaquin Water Conservation District has reviewed those portions of the Preliminary Draft of Bulletin No. 11, as modified by the above referenced Major Corrections, which are considered of interest and concern to residents and property owners within the Eastern Mokelumne Unit, and particularly those within the boundaries of the North San Joaquin Water Conservation District.

In some instances, the district finds itself at variance with the conclusions expressed in the bulletin, as modified by the September 15, 1955, corrections. Certain of the variances are here summarized under the following headings—all of which have reference to the Eastern Mokelumne Unit:

I. Estimated Seasonal Consumptive Use of Water
II. Estimated Safe Seasonal Ground Water Yield
III. Future Water Supply for Underground Water Basin
IV. Future Water Requirements
V. Plans for Initial Local Development

Considering these subjects in order, the following comment is made:

I. ESTIMATED SEASONAL CONSUMPTIVE USE OF WATER

(Ref. Major Corrections, p. 12, Table 33)

Applied Water:

The bulletin sets forth estimates for "consumptive use" of "applied water," determined for the entire San Joaquin area. It is believed that the character and development of the Eastern Mokelumne Unit is such that a higher use of "applied water" within its boundaries should be recognized. Predicated upon available information, the consumptive use of "applied water" recommended for the Eastern Mokelumne Unit—as compared to that set forth in the Major Corrections for the San Joaquin Area—is as follows:

CONSUMPTIVE USE OF "APPLIED WATER" IN FEET OF DEPTH PER SEASON

Class and type of land use	*Bulletin determination for San Joaquin Area*	*Recommended value for Eastern Mokelumne Unit*
Irrigated lands		
Permanent pasture	2.55 feet	2.75 feet
Vineyards	1.19 feet	1.5 feet
Deciduous orchards	1.68 feet	1.8 feet
Alfalfa	2.45 feet	2.75 feet
Beans	1.11 feet	
Tomatoes	1.62 feet	
Rice	4.60 feet	2.0 feet (weighted average omitting "rice")
Truck	0.93 feet	
Asparagus	1.92 feet	
Sugar beets	1.69 feet	
Miscellaneous	1.11 feet	
Miscellaneous		
Urban	2.10 feet	3.0 feet
Farmsteads	.90 feet	1.5 feet *
		2.0 feet †

* 1.5 feet average use for Land Use development of Eastern Mokelumne Unit for Base Period (1939-'40 through 1950-'51)
† 2.0 acre feet average seasonal use for future Land Use development.

* * * * *

Precipitation

Precipitation within the area not accruing to "outflow" is considered in the bulletin as either "Consumptively Used" (through evaporation or transpiration), or as accruing to the underground water basin. This results in a determined contribution to the area underground water supply from this source far in excess of observed amounts.

It is believed the preponderance of data, evidence and qualified opinion indicates that substantially all of the precipitation accruing to the Eastern Mokelumne Unit is either consumptively used through transpiration and evaporation, or is conveyed beyond the area either by natural or artificial drainage works. The amount accruing to the underground water basin by direct rainfall penetration in the Eastern Mokelumne

Unit is believed to be relatively small both in total quantity, and particularly in relation to the other sources of underground water supply. Such were the conclusions of B. A. Etcheverry, Thomas H. Means and Paul Bailey, reached from study of the USGS field and laboratory measurements and determinations and other data obtained or made available to them, and were a part of their testimony in the *Lodi* v. *EBMUD* trial.

* * * * *

II. ESTIMATED SAFE SEASONAL GROUND WATER YIELD OF EASTERN MOKELUMNE UNIT

(Ref. Major Corrections, p. 9, Table 19)

Computations in Table 19 of the Major Corrections determine the "Safe Ground Water Yield" for the Eastern Mokelumne Unit to be 60,600 acre-feet per season under "present conditions" for long-term average seasonal conditions. Such estimate is described on pp. 2-54 of the bulletin, in the following language:

"The foregoing estimate of safe seasonal ground water yield may be considered to represent the net seasonal extraction from the ground water basin that might be maintained without permanent lowering of the water table beyond conditions prevailing in 1952. Having so chosen the determining criteria, estimated safe seasonal ground water yield may be considered to be a property of the ground water basin, not affected by changes in irrigation efficiency, patterns, or practices."

These are important estimates and assumptions insofar as the Eastern Mokelumne Unit, and particularly the North San Joaquin Water Conservation District, are concerned. Water furnished by and pumped from the underground water basin supplies practically all of the irrigation, domestic, municipal and other water users within the area, and is essential to the prosperity of the inhabitants thereof. Since the supply to the underground water basin within this area is deficient, any impairment or loss of supply will adversely affect the North San Joaquin Water Conservation District. For these reasons, full consideration of the following is requested:

Summarized, the sources of Safe Ground Water Yield for the Eastern Mokelumne Unit, as determined by the data and methods set forth in the Major Corrections, pp. 3 and 4, Table 9; p. 6, Table 17; p. 9, Table 19, and Bulletin No. 11 (April 1954 edition) p. 3-8, Table 26, are as follows:

(All quantities are in acre-feet per season)

SURFACE INFLOW (Table 19)			779,900
Sources (Table 9):			
Mokelumne River		669,300	
Dry Creek	96,300		
Dry Creek—Sacramento County	3,500		
		99,800	
Bear Creek		7,500	
Total of above			776,600
Balance "Minor drainage"			3,300

* * * * *

SURFACE OUTFLOW (Table 19)		752,400
Adjustment for "present conditions" (footnote (b), p. 9, major corrections)		1,400
Outflow for base period		753,800
Sources:		
Mokelumne River (Table 9) 525,800		
Woodbridge Irrigation District Diversions (from Table 26) 113,370		
Total—Mokelumne River outflow	639,170	
Dry Creek	96,700	
Total of above		735,870
Balance "Bear Creek" and "unmeasured outflow"		17,930
SURFACE INFLOW MINUS SURFACE OUTFLOW (from above)		
Mokelumne River inflow	669,300	
Mokelumne River outflow (incl. W.I.D.)	639,170	
Mokelumne River use and loss in Eastern Mokelumne Unit		30,130
Dry Creek inflow	99,800	
Dry Creek outflow	96,700	
Dry Creek use and loss in Eastern Mokelumne Unit		3,100
Total loss and use—Mokelumne River and Dry Creek in Eastern Mokelumne Unit		33,230
Bear Creek inflow 7,500		
"Minor drainage" inflow 3,300		
Total Bear Creek and "minor drainage" inflow	10,800	
Bear Creek and "unmeasured outflow"	17,930	
Excess of outflow over inflow (Bear Creek, "minor drainage" and "unmeasured outflow")		—7,130
Excess of surface inflow over surface outflow for "base period"		26,100
Adjustment for "present conditions"		1,400
Excess of surface inflow over surface outflow for "present conditions"		27,500
PRECIPITATION:		
Base period average (Table 19)	153,000	
Consumptive use "present conditions" (Table 19)	121,700	
Present percolation loss and use of precipitation		31,300
UNDERGROUND INFLOW (Table 19)		10,000
Total supply for loss and use in unit		68,800
"Mean consumptive use" of "applied surface water" under "present conditions" (Table 19)		8,200
Balance "Safe Ground Water Yield," as determined in Table 19		60,600

Without allowances for surface diversions, evaporation and transpiration from any of the surface sources of supply; without allowances for underground percolation from Dry Creek into Sacramento County; and without allowances for the runoff of precipitation from the City of Lodi which results from storm drains discharging into the Woodbridge Irrigation District Canal, and at the western side of the Western Mokelumne Unit, and using only the exact data and methods employed in the bulletin and the major corrections thereto, the sources of the "Safe Ground Water Yield" are as follows:

(All quantities are in acre-feet per season)

SOURCE OF SAFE GROUND WATER YIELD	*Gross amount of loss and use in unit*
Mokelumne River	30,130
Dry Creek	3,100
Precipitation (within unit)	31,300
Underground inflow	10,000
	74,530

Taking the Mokelumne River as an example:	
Gross loss and use	30,130
Allowances for "base period" evaporation, transpiration and surface diversions from Clements to Woodbridge (W.I.D. not included) say	13,000
Approximate indicated percolation into underlying ground water basin	17,130
Say—17,000 acre-feet per year or season	
For Dry Creek:	
Gross loss and use	3,100

A reasonable allowance for evaporation, transpiration and surface use, plus a reasonable assumption that about one-half of the Dry Creek percolation is contributed to the underground water supply of the adjoining lands in Sacramento County (outside the Eastern Mokelumne Unit) would make any percolation from Dry Creek into the Eastern Mokelumne Unit under the methods of determination employed in the bulletin, a very small quantity.

The quantitative accuracy of all the foregoing quantities is dependent upon the accuracy of all the measurements and estimates employed in the calculations, including the inflow and outflow from both surface and underground sources, precipitation and the consumptive use thereof, the consumptive use of applied surface water, etc.—all of which are believed to be extremely difficult and practically impossible to estimate under most favorable conditions to accuracies of the quantitative determinations set forth in the bulletin and major corrections for the contributions of the various elements of ground water supply.

For example, inaccuracies of 2 percent in Mokelumne River and Woodbridge District Canal stream flow measurements can result in an increase of 87 percent in the computed gross loss and use of Mokelumne River water within the Eastern Mokelumne Unit.

Not founded on conclusive data, but supported by good evidence and considered well within the probable limits of accuracy of both the bulletin data and the determinations predicated thereupon, are the following estimated average seasonal contributions to the Eastern Mokelumne Unit underground water basin for the base period. These estimates are submitted for comparison with the comparable factors determined solely from bulletin data by bulletin methods, as hereinabove set forth.

SOURCE OF UNDERGROUND WATER SUPPLY	*Average seasonal contribution for base period*
Mokelumne River percolation	48,870 acre-feet
Subsurface inflow	11,077 acre-feet
Precipitation within unit	a minor amount see p. 3, supra
Dry Creek percolation	5,213 acre-feet
Total	65,160 acre-feet

* * * * *

III. FUTURE WATER SUPPLY FOR UNDERGROUND WATER BASIN

Present and increasing upstream diversions will decrease percolation from the Mokelumne River accruing to the Eastern Mokelumne Unit. Presumably, appropriate legal steps will be taken with respect to any such nonriparian diversions to insure compensation or a physical solution preserving the supply within the unit. It would seem, however, that as a matter of over-all planning from the standpoint of water utilization (omitting for this purpose, consideration of the landowner's legal rights) study might well be given to a projection of the effect upon underground water supply if full utilization were to be made under presently existing permits and licenses, such as those of the East Bay Municipal Utility District for municipal and power purposes.

The upstream diversions occurring during the base period were less than those which must be contemplated under present conditions, and appreciably less than those which must be expected if the presently sought requirements of upstream appropriators are to be fulfilled.

Predicated upon mean climatic conditions, the Mokelumne River percolation which will result under immediate future diversions will be less than the base period percolation and will progressively decrease with the increase in upstream diversions.

Also, the water available for surface diversions and uses important to maintenance of the Eastern Mokelumne Unit water supply will decrease. This will increase the use of underground water. It will likewise progressively decrease the replenishment of the underground water basin from the use of surface water below the replenishment which occurred during the base period—both the percolation from surface water irrigation within the Eastern Mokelumne Unit, and underground inflow from the Western Mokelumne Unit which accompanies the heavy use of surface water diversions for irrigation supplied through the Woodbridge Irrigation District's works.

* * * * *

IV. FUTURE WATER REQUIREMENTS

(Ref. Bulletin pp. 3-22 and 23, Table 30; Major Corrections, p. 14, Table 36; p. 20, Table 41)

As determined in the bulletin, the future water requirements for the Eastern Mokelumne Unit are a summation of the products of the separate use areas times the respective unit consumptive uses, both for applied water and for precipitation. For this method, the bulletin and other available data indicate that the ultimate land use of the Eastern Mokelumne Unit may be expected to approximate the following:

Land use	*Ultimate acreage*
Irrigated land:	
Permanent pasture and alfalfa	50,500
Vineyards	22,000
Orchards	3,000
Rice	500
Other	12,000
Total irrigated	88,000
Urban	5,600
Farmsteads	2,500
Total	96,100

(Other ultimate land use area assumptions same as set forth in bulletin.)

Applying the "recommended" consumptive use factors as set forth under "I," (p. 2), to these estimated land uses, gives an indicated ultimate "consumptive use" of "applied water" requirement of about 225,-500 acre-feet per annum on the average. Such "consumptive use" of "applied water" quantity is in addition to the consumptive use of water supplied by direct precipitation upon the lands within the unit. The "supplemental water requirements" which will be necessary to provide for the full economic development of the area will, of course, be dependent upon the then available supply from the presently supplying sources. Predicated upon existing sources with the reasonably certain reduction in supply which must be anticipated, it is considered probable that the

	Acre-feet
Ultimate mean seasonal supplemental water requirement of the Eastern Mokelumne Unit will be more nearly	165,000
as compared to	
Corresponding estimated quantity of (p. 20, Table 41, Major Corrections)	126,800
An increase of	38,200 per season

on the average, over the bulletin's determination for "probable ultimate mean seasonal supplemental water requirement."

The "present supplemental water requirement" for the Eastern Mokelumne Unit must take into account the immediate future requirements for water within the unit, as well as the probable supply conditions that will prevail in the immediate future. The probable quantitative diversions in the Mokelumne River can be closely approximated, but assumptions are necessary regarding the regulation of the remaining flow, the probable climatic conditions that may prevail and the effect thereof on each of the supplying sources. Whether the 28,500 acre-feet "present supplemental water requirement," as set forth in the major corrections, p. 20, Table 41, for the unit will suffice is problematical. The true significance of the quantity designated in the estimate is difficult to assess, unless the term is more fully defined.

If the term "present supplemental water requirement" is taken to mean the amount of additional water that should be presently supplied for either direct use as "applied water," or added to the supply to balance the underground water basin, so as to furnish the water required to continue both the past productivity and normal growth of the area, then—considering the present reductions in the existing sources of supply and increases in all water uses subsequent to 1951-1952—the supplemental water requirement is estimated by the district at about 40,000 acre-feet per season. The actual future supplemental water requirement, including the reasonably expected increase thereof, are matters which will be determined by the future area development and the then occurring climatic conditions.

V. PLANS FOR INITIAL LOCAL DEVELOPMENT

The North San Joaquin Water Conservation District has on file with the Division of Water Resources certain applications for permits to appropriate water to be pumped from the Mokelumne River at Clements and Lockeford and distributed to lands within the district. It is contemplated that water so appropriated will be supplied for direct irrigation and consumed by municipal, agricultural and other beneficial uses within the area, both by direct surface application and also through the replenishment of the underground water storage basin supplying the area.

By utilization of surface flow when available, first for direct irrigation, and second, for recharging the underground water basin, water which now flows to waste can be put to beneficial use. It is recognized that the quantity of water available for such purposes will materially diminish as upstream diversions are increased and that unfavorable climatic conditions could render such works inoperable for appreciable periods of time. However, preliminary hydrographic investigation and economic analysis indicate such plan may well be the first step taken in providing the additional water required for the continued prosperity as well as the reasonably expected growth and most economic development of the area.

The North San Joaquin Water Conservation District's Mokelumne River applications also include the construction of Mehrten Reservoir to a capacity of 50,000 acre-feet. When the Mehrten Reservoir would be constructed is a matter which is largely dependent upon the development of factors such as the future diversions and operating program of the East Bay Municipal Utility District. Construction of Mehrten Reservoir within the immediate future might prove to be economically desirable unless a suitable definite plan of operation for Pardee Reservoir can be obtained.

The data expected to be developed in the present hearing before the Division of Water Resources on the Mokelumne River applications will undoubtedly appreciably affect the North San Joaquin Water Conservation District's program for the construction of both storage and diversion works on the Mokelumne River.

Very truly yours,

NORTH SAN JOAQUIN WATER
CONSERVATION DISTRICT
By: LE MOIN BECKMAN, President

STOCKTON AND EAST SAN JOAQUIN WATER CONSERVATION DISTRICT

November 14, 1955

STATE WATER RESOURCES BOARD
Public Works Building, Sacramento 5, California

Attention: Mr. Harvey O. Banks, Acting State Engineer, Secretary

Re: Preliminary draft of Bulletin No. 11, dated April, 1954, and major corrections thereto, dated September 15, 1955

GENTLEMEN: The Stockton and East San Joaquin Water Conservation District has reviewed those portions of the preliminary draft of Bulletin No. 11 and major corrections thereto, which are considered of interest and concern to residents and property owners within the Calaveras Unit, and also certain areas within the adjoining Western Mokelumne and Littlejohns Units in which urban development of the Stockton metropolitan area is expected.

In some instances the district finds itself at variance with the conclusions expressed in the bulletin, as modified by the major corrections. Certain of the variances are summarized under the following headings—all of which have reference to the Calaveras Unit, and the adjoining portions of the Western Mokelumne and Littlejohns Units expected to be occupied by Stockton metropolitan urban area developments.

I. Estimated Seasonal Consumptive Use of Water
II. Present and Future Water Requirements
  A. Land Use
  B. Water Consumption
III. Estimated Future Safe Seasonal Ground Water Yield
IV. Supplemental Water Requirements
V. Plans for Initial Local Development

Considering these subjects in order, the following comment is made:

I. ESTIMATED SEASONAL CONSUMPTIVE USE OF WATER

(Ref. Bulletin, p. 3-22, Table 30; Major Corrections, p. 11; Table 32; p. 12, Table 33; p. 14, Table 37)

Table 33 sets forth estimates for "consumptive use" of "applied water," as determined for the entire San Joaquin area for specific crop production. The unit values thus determined are then applied to the respective areas determined in accordance with "Land Use," as set forth in Table 30, and as similarly estimated in Table 32 for the ultimate land use. The product thereof determines the estimated seasonal consumptive use of water within the various hydrographic units, as set forth in Table 33, and Table 37. Basically, the "totals" given for the unit values of "seasonal consumptive use" for the various crops are generally considered close to the actual values of the "unit values of seasonal consumptive use" for the specific crops listed in Table 33, and for the periods of time considered. The major exception is an appreciable variance which is believed indicated by the value assigned for "Truck" which is quite low for intensively farmed multiple crop truck gardens. Altogether, the total consumptive use factors are believed to be somewhat low for the recent past and particularly for the reasonably prospective future consumptive use of water for the various crop areas within the Calaveras Unit for the following reasons:

A. The recent and progressively increasing use of scientifically compounded and applied fertilizers is
   1. increasing the productivity of all crops
   2. encouraging the double or multiple cropping of the highly productive lands within the irrigated areas not devoted to permanent crops such as orchards and alfalfa.

   Both the preceding numbered factors and particularly the latter tend to increase the consumptive use within the areas.

B. The prevailing cultivation pattern, determined primarily by the economy of farming operations, results in the growth of noncrop producing vegetation. This is more pronounced during the actual crop growing season, and creates a consumptive use through transpiration in addition to that occasioned by the actual crops produced. Recognition thereof is therefore necessary in the determination of the total consumptive use for the respective crop areas, particularly those areas under irrigation.

C. Precipitation within the area is considered in the bulletin as either "consumptively used" (through evaporation or transpiration) or as accruing to the underground water basin. This results in indicated contribution to the area underground water supply from this source far in excess of observed amounts.

It is believed the preponderance of data, evidence and qualified opinion indicates that substantially all of the precipitation occurring within the Calaveras Unit is consumptively used through transpiration and evaporation and that the balance is conveyed beyond the area either by natural or artificial drainage. The amount accruing to the underground water basin by direct rainfall penetration in the Calaveras Unit is believed to be relatively small both in total quantity, and particularly in relation to the other sources of underground water supply. Such were the conclusions reached by B. A. Etcheverry, Thomas H. Means and Paul Bailey, for the comparable Mokelumne River area to the north of the Calaveras Unit from study of the USGS field and laboratory measurements and determinations and other data obtained or made available to them, and were a part of their testimony in the case of *Lodi* v. *East Bay Municipal Utility District.* Although the runoff from agricultural areas is relatively light in normal years, for the long-term average it is an appreciable factor for which allowances should be made in the determination of the average amount of precipitation available for transpiration and evaporation. Similarly, during periods of low precipitation and in accordance with the precipitation pattern and intensities of the area, reductions will occur in the amount of precipitation available for consumptive use, which is limited to the total precipitation less the actual runoff. Some runoff will occur even in the lowest rainfall years from the more impervious and the paved areas. Such runoff is and will be conducted outside of the area through artificial and natural drainage.

It is believed that further investigation and consideration of the sources of the runoff, together with amount of precipitation available for consumptive use in both the normal and particularly, the sub-normal periods of precipitation will indicate (a) an increase in the average consumptive use of precipitation through evaporation, and noncrop producing vegetation during the above normal periods of rainfall, and (b) a decrease in consumptive use of precipitation in the dryer periods.

Summing up all the above factors leads to the conclusion that for estimating the future water requirements necessary to provide for the full economic development of the area requires certain increases in the bulletin determinations of past consumptive use, particularly in the values of "consumptive use" estimated for "applied water." Further, it is deemed appropriate to consider all except a small increment of precipitation as either (a) consumptively used by all supported vegetation including noncrop producing plants with ample allowances for evaporation from all wetted surfaces following precipitation, or as (b) accruing to the runoff of the area through natural or artificial drainage works.

Only a small increment of precipitation occurring in above normal rainfall season is believed to penetrate below the root zone. Such rainfall penetration is considered as a very minor source of replenishment to the underground water supply.

In keeping with the preceding outlined factors, for determination of the future water requirements of the Calaveras Unit, the following "Recommended future values for Calaveras Unit" for the "Consumptive Use of 'Applied Water' in feet of depth per season" are considered applicable:

CONSUMPTIVE USE OF "APPLIED WATER" IN FEET OF DEPTH PER SEASON

Class and type of land use	*Bulletin determination for San Joaquin Area*	*Recommended future values for Calaveras unit*
Irrigated Lands		
Permanent pasture	2.55 feet	2.75 feet
Vineyards	1.19 feet	1.5 feet
Deciduous orchards	1.68 feet	1.8 feet
Alfalfa	2.45 feet	2.75 feet
Beans	1.11 feet	2.0 feet (Weighted average for anticipated intensified agricultural production, excluding rice)
Tomatoes	1.62 feet	
Rice	4.60 feet	
Truck	0.93 feet	
Asparagus	1.92 feet	
Sugar beets	1.69 feet	
Miscellaneous	1.11 feet	
Miscellaneous		
Urban	2.10 feet	
Gross 12,200 acres urban area (present)		2.9 feet
Net occupied urban area		3.4 feet
Farmsteads	.90 feet	
1955 development		1.5 feet
Ultimate development		2.0 feet

II. PRESENT AND FUTURE WATER REQUIREMENTS

The bases for the herein set forth comparisons between "present" and "ultimate" water requirements are not exactly comparable inasmuch as

1. The bulletin considered the "present" water requirement as that estimated for the season 1951-1952, whereas the district's estimates most nearly comparable are predicated upon estimated conditions expected to prevail in 1955, assuming normal seasonal conditions of both precipitation and of crops and markets.

2. The bulletin estimates are for consumptive use of water within the Calaveras Unit, whereas the District's estimates include both the Calaveras

Unit and certain separately set forth areas outside thereof in which urban developments of Metropolitan Stockton are anticipated.

3. The bulletin utilizes for its analyses a 12-season "base period" including the seasons 1939-1940 through 1950-1951 with certain adjustments for the hydrographic conditions prevailing during the three-year period 1949-1950 through 1951-1952, adjusted to 1951-1952 land use conditions, whereas the district's estimates are predicated primarily upon the actual urban land use developments determined in 1954 and the use of water as determined by the records of water supplied by the California Water Service Company for the 12-month period ending about June 30, 1954, adjusted for estimated average seasonal conditions for certain then prevailing additional urban uses, all as modified and estimated for 1955 land use conditions.

4. The bulletin sets forth separate estimates for the unit consumptive use of "applied" water and "precipitation" but combines both in the estimated quantities given for total consumptive use. The district's estimates are for consumptive use of "applied" water.

The above, notwithstanding the comparisons hereinafter set forth, are believed to indicate certain variances in the estimates which are worthy of presentation for your consideration.

II. A. LAND USE

(Ref. Bulletin No. 11, p. 3-22 and 23, Table 30; Major Corrections, p. 11, Table 32)

The "present" 1951-1952 land use for the Calaveras Unit, as set forth in Table 30 of the bulletin, condensed by grouping land uses in accordance with somewhat similar water requirements, is compared with estimated "present" and future land use requirement for the Calaveras Unit in Table I following. The "present 1951-1952" 12,220 acres of urban development, as set forth in the bulletin for the Calaveras Unit, includes certain areas which are vacant or undeveloped for urban use, as well as certain agricultural use areas which are embraced within the general urban limits. This is also true, to a somewhat lesser degree, for the 1955 urban land estimate. Consequently, such 12,220 acres of urban area for the 1951-1952 and the 1955 estimates are not directly comparable. Both are on different bases than the estimated ultimate urban area of 17,500 acres, which is predicated upon the net area expected to be occupied by all the urban developments and the embraced directly supporting facilities, such as water surfaces, drainage ways, etc., and also the "waste lands." The comparable 1955 area occupied by urban development is estimated to be about 10,500 acres.

TABLE I

PAST AND ESTIMATED FUTURE LAND USE IN ACRES FOR CALAVERAS UNIT

Use	*From the bulletin "present 1951-1952"*	*Estimated for 1955*	*Estimated for Ultimate*
Irrigated lands			
Permanent pasture and alfalfa	10,130	11,140	21,170
Vineyards	90	90	
Orchards	17,860	17,860	18,000
Rice	790	790	
Miscellaneous ‡	15,610	17,170	20,000
Total irrigated	44,480	47,050	59,170
Dry farmed and fallow	24,210	21,500	2,100
Native vegetation	260	250	200
Miscellaneous			
Urban	12,220*	12,220*	17,500†
Farmsteads	1,530	1,600	2,500
Roads, highways and railroads	2,220	2,300	3,450
Water surface and waste lands	1,050	1,050	1,050
Subtotal	17,020	17,170	24,500
Total	85,970	85,970	85,970

* Gross urban area, including embraced vacant and agricultural land uses.
† Net developed urban land use area.
‡ Includes area expected to be devoted to beans, tomatoes, truck, asparagus, sugar beets and similar miscellaneous crops, which will be more intensively farmed in the future by double cropping.

The ultimate land use for the Calaveras Unit, as given in the major corrections, p. 11, Table 32, is compared with the corresponding estimates set forth in Table I preceding, in Table II following.

TABLE II

COMPARISON OF BULLETIN NO. 11 PROBABLE ULTIMATE LAND USE WITH ULTIMATE LAND USE ESTIMATES IN TABLE I

Use	*Bulletin No. 11*	*This comment*
Irrigated lands	58,600 acres	59,170 acres
Dry farmed lands	2,100 acres	2,100 acres
Native vegetation	200 acres	200 acres
Miscellaneous	25,070 acres	24,500 acres
Total	85,970 acres	85,970 acres

The differences between the quantities set forth for "Irrigated Lands" and "Miscellaneous" are believed due primarily to the difference between gross urban area land use basis considered in the bulletin, as compared to the occupied area basis used in the "estimate for"—"ultimate," set forth in Table I, and also to anticipated growth of the Stockton metropolitan urban area outside of the Calaveras Unit.

A factor worthy of serious consideration is that perhaps two-thirds of the future Stockton metropolitan urban area development will occupy adjacent lands within both the Western Mokelumne and Littlejohns Units. Sufficient allowance to provide the area expected to be required thereby is not apparent from the data set forth in Table 30 of the bulletin and Table 32, p. 11 of the major corrections. The presently estimated future population for the Stockton metropolitan area with corresponding estimates for the land expected to be occupied by the urban development is set forth in Table III following. Since this urban development will constitute either a demand for additional water supply within the Calaveras Unit, or will decrease the supply which will be available from areas presently supplying water to the Calaveras Unit through underground inflow, such urban development should be taken into account in the determinations of the supplemental water supply required for the Calaveras Unit.

TABLE III

ESTIMATED STOCKTON METROPOLITAN AREA AND POPULATION

Year	*Population*	*Area occupied*
1955	135,000	11,800 acres
Sometime between 1970-1975	220,000	19,025 acres
Ultimate	400,000	34,325 acres

* * * * *

II. B. WATER CONSUMPTION

(Ref. Major Corrections, p. 13, Table 35; Table 37, p. 14; Table 41, p. 20)

The "estimated mean consumptive use of water" for the "Calaveras Unit" under "present pattern of land use" is given in Table 35—as 201,100 acre-feet. Of this amount, approximately 93,300 acre-feet is supplied by precipitation according to the data set forth in the major corrections, p. 9—Table 19. The balance of 107,800 acre-feet represents the consumptive use of applied water.

Similarly, the "Probable Ultimate Mean Seasonal Consumptive Use of Water * * *" for the "Calaveras Unit" is given in Table 37 as 234,500 acre-feet. Of this amount about 92,500 acre-feet will probably be supplied by precipitation according to the bulletin data. The balance of 142,000 acre-feet represents the consumptive use of applied water.

The present and ultimate consumptive use of applied water as above determined from the bulletin data are compared with corresponding estimates made by the district in Table IV following.

TABLE IV

COMPARISON OF PRESENT AND ULTIMATE CONSUMPTIVE USE OF APPLIED WATER AS DETERMINED FROM BULLETIN DATA WITH CORRESPONDING ESTIMATES

ESTIMATES FOR CALAVERAS UNIT ONLY	*Average annual consumptive use*
Present	
Estimated for 1955	
For the 12,220 acre gross urban area	35,631 acre-feet
Other area	103,416 acre-feet
Total	139,047 acre-feet
Bulletin "Present" (1951-1952)	107,800 acre-feet
Increase over Bulletin estimates	31,247 acre-feet
Ultimate	
Estimated 17,500 acres occupied urban area	58,833 acre-feet
Other area	135,618 acre-feet
Total	194,451 acre-feet
Bulletin "Ultimate"	142,000 acre-feet
Increase over Bulletin estimates	52,451 acre-feet

The above 52,451 acre-feet increase over the bulletin's estimate for the anticipated consumptive use for the ultimate land use development contemplated for the Calaveras Unit will be accompanied by a very material increase in urban development of the Stockton metropolitan area to the north, within the Western Mokelumne Unit, and also to the south, within the Littlejohns Unit. The total occupied urban land estimated for the ultimate urban development within the Calaveras Unit and that portion of the Stockton metropolitan area outside thereof is 34,325 acres, of which about 17,500 acres are expected to be within the Calaveras Unit. Occupied Stockton metropolitan urban area expected to develop outside the Calaveras Unit therefore would be about 16,825 acres. The total estimated average annual consumptive use of "applied" water required by the ultimate Stockton metropolitan developed urban area outside the Calaveras Unit is estimated at 57,662 acre-feet.

Excluding the area irrigated through the Woodbridge Irrigation District's works by surface diversions from the Mokelumne River (all north of Calaveras River), about one-half the balance of the area in which Stockton metropolitan urban development is anticipated is irrigated from wells. The remainder is either vacant, fallow or dry-farmed. A rough approximation of the areas expected to be occupied by urban Stockton developments outside the Calaveras Unit is:

- $\frac{1}{5}$ within area which is presently considered as area irrigable by surface diversions from the Mokelumne River through Woodbridge Irrigation District's works;
- $\frac{2}{5}$ within area classified as dry-farmed or fallow lands; and
- $\frac{2}{5}$ within lands irrigated with water obtained from the underlying ground water basin.

The lands irrigated through the Woodbridge Irrigation District's works in which such Stockton urban development is expected, are primarily used for producing rice, alfalfa and clover. The application of water to such crops is known to be large and, although the soil is relatively impervious, the weighted average annual contribution toward replenishment of the underlying ground water basin is probably in excess of $3\frac{1}{2}$ feet per annum per acre irrigated, including the distribution canal losses. It is estimated that 3,365 acres ($\frac{1}{5}$) of such urban expansion will be in areas presently considered as irrigable from the Woodbridge Irrigation District's works, of which about one-half, or some 1,680 acres, is irrigated each year. Adding to such 1,680 acres the 920 acres recently excluded from the area irrigated through the Woodbridge Irrigation District's works (due primarily to the encroachment of the Stockton metropolitan urban development within the Western Mokelumne Unit), gives a total of 2,600 acres of area presently or recently contributing to the replenishment of the underlying ground water basin, which has been or will be lost due to urban area development. Assuming $3\frac{1}{2}$ acre-feet per acre average percolation into the underlying ground water basin from such 2,600 acres, including canal losses, this represents a loss in underground water replenishment of 9,100 acre-feet per annum, due to the recent and anticipated replacement of areas irrigated with Mokelumne River water, by recent and future urban developments.

An average annual consumptive use of applied water approximating two acre-feet per acre is believed applicable to the lands presently irrigated from wells and in which Stockton urban area is expected to develop. Such urban area development is estimated to be two-fifths of the total expected outside urban area development, or as replacing 6,730 acres of agricultural land use divided between the adjacent Western Mokelumne and Littlejohns Units which are presently irrigated from wells. This indicates an average decrease in the agricultural consumptive use of 13,460 acre-feet per annum. The difference between such 13,460 acre-feet of discontinued agricultural consumptive use and 9,100 acre-feet of replenishment lost by elimination of lands irrigated through the Woodbridge Irrigation District's works, represents a net increase in water available for the urban developments of about 4,360 acre-feet per annum. Subtracting this from the estimated 57,662 acre-feet per annum estimated water requirement for the ultimate urban development expected within such outside areas, gives an indicated average net increase of about 53,302 acre-feet per annum, for the areas presently supplying water to the Calaveras Unit through underground inflow. Thus, for purposes of estimating the ultimate water requirements of the Calaveras Unit, plus the adjoining Stockton metropolitan area ultimate urban land developments estimated to occupy some 16,825 acres outside the unit, requires the adjustments in the ultimate average annual consumptive use of water, as set forth in Table V following.

TABLE V

COMPARISON OF AVERAGE ANNUAL ULTIMATE CONSUMPTIVE USE OF APPLIED WATER AS DETERMINED FROM BULLETIN DATA FOR CALAVERAS UNIT ONLY WITH ESTIMATES FOR CALAVERAS UNIT AND STOCKTON URBAN REQUIREMENTS OUTSIDE THEREOF

	Acres	*Acre-feet consumptive use*
Estimated ultimate developed urban area	34,325	116,495
Decrease for difference between present replenishment and consumptive use replaced (p. 15)		4,360
Net increase due to urban development		112,135
Other Calaveras Unit area	68,470	135,618
Total	102,795	247,753
Bulletin ultimate for Calaveras Unit *only*	85,970	142,000
Differences	16,825	105,753
	(less)	(more)

* * * * *

Whether the artificial boundaries as established in the bulletin for the Calaveras Unit and by the Stockton and East San Joaquin Water Conservation District are adjusted to include the anticipated Stockton urban area developments outside such artificial boundaries is of no moment insofar as determining the ultimate water requirements of the Stockton and East San Joaquin Water Conservation District is concerned. Therefore, the difference of 105,753 acre-feet in average annual water requirements is of concern to the conservation district.

III. ESTIMATED SAFE SEASONAL GROUND WATER YIELD OF CALAVERAS UNIT

(Ref. Major Corrections, p. 9, Table 19)

Computations in Table 19 of the bulletin determine the "safe ground water yield" for the Calaveras Unit to be 80,100 acre-feet per season under "present conditions" for long-term average seasonal conditions. This is believed to be a close approximation for the periods used for determining the estimate. However, the presently changing and anticipated future circumstances affecting water supply and requirement within the region of concern strongly indicate an appreciable and progressively decreasing "safe ground water yield" is to be expected from the underground water reservoir underlying the Calaveras Unit.

The "safe ground water yield" estimate is described on p. 2-54 of the bulletin, in the following language:

"The foregoing estimate of safe seasonal ground water yield may be considered to represent the net seasonal extraction from the ground water basin that might be maintained without permanent lowering of the water table beyond conditions prevailing in 1952. Having so chosen the determining criteria, estimated safe seasonal ground water yield may be considered to be a property of the ground water basin, not affected by changes in irrigation efficiency, patterns, or practices."

These are important estimates and assumptions insofar as the Calaveras Unit, and particularly the Stockton and East San Joaquin Water Conservation District, are concerned. Water furnished by and pumped from the underground water basin supplies practically all (some 88 percent) of the irrigation, domestic, municipal and other water users within the area, and is essential to the prosperity of the inhabitants thereof. Since there is presently an overdraft on the underground water basin within this area, any impairment or loss of yield will adversely and seriously affect the economic growth and prosperity of the Stockton and East San Joaquin Water Conservation District. For these reasons, full consideration of the following is requested.

1. The estimated 80,100 acre-feet safe ground water yield included an estimate of 35,500 acre-feet of "subsurface inflow" for "mean water supply under present conditions"; such "present condi-

tions'' being the ''averages for three-year period, 1949-1950 through 1951-1952,'' given in Table 17, p. 6, of the major corrections. As indicated by underground water contours on Plate 9 of the bulletin, it is believed evident that more than one-half of the subsurface inflow comes from the Western Mokelumne Unit and is primarily attributable to the heavy use of Mokelumne River water diverted through Woodbridge Irrigation District's works and applied within the southern portion of the Western Mokelumne Unit for irrigation. As previously mentioned, (pp. 13 and 16) this replenishment of underground supply will diminish with the displacement of such irrigated areas and the canals required therefor, by expected Stockton urban developments within this area. Also to be considered is further decrease in underground water replenishment presently attributable to the Woodbridge Irrigation District's works, which will accompany relatively certain decreases in the Woodbridge Irrigation District's diversions as less water becomes available from the Mokelumne River for that purpose, due to the increases in diversions from the Mokelumne River by the East Bay Municipal Utility District. A very good example of this is the 1955 curtailment of water service for rice, which was previously supplied by the Woodbridge Irrigation District to lands south of the Eight-Mile Road.

2. The above-mentioned underground water contours indicate the next in order of magnitude is the underground inflow of water from the Littlejohns Unit which probably accounts for over half of the underground inflow other than that accruing from the Western Mokelumne Unit. As indicated by the graph entitled ''Littlejohns Unit'' on Plate 11 of the bulletin, and also by the ''Lines of Equal Change in Ground Water Elevations,'' given on Plates 12 and 13 (as well as the above-mentioned underground water contours), and considering the potential and anticipated water-using developments within the Littlejohns Unit, the future underground inflow from this source will probably diminish, and unless a supplemental surface water supply is obtained and used within the Littlejohns Unit, the underground water flow may reverse and thus a serious loss can and probably will result in the replenishment of the ground water reservoir underlying the Calaveras Unit.

3. The balance of the underground inflow from other than the Western Mokelumne and Littlejohns Units accrues from the foothill region lying east of the Calaveras Unit and from the San Joaquin River Delta region lying west of the Calaveras Unit. The relatively impermeable underground formations west of Stockton indicate contribution from the foothill region probably has been the larger of the two. Due to the prevailing high mineral content of the ground water in the Delta regions, any increase in the underground inflow therefrom is not desirable and to provide insurance against deterioration of Stockton's present water supply the existing underground water sink underlying Stockton should not be increased in depth. In fact, such sink should be eliminated insofar as practicable by either decreased draft on the ground water basin or by supplementing the replenishment thereto. Consequently, the replenishment of the ground water basin underlying the Calaveras Unit from the Delta region to the west thereof is not expected to increase appreciably under anticipated future conditions and a decrease therein is desirable and should be contemplated in plans for future water supply.

4. Contributions of underflow from the foothill regions into the Calaveras Unit may increase somewhat with the increasing gradient of the underground water surface which is expected to prevail for a few years. This underground movement of waters will drain the permeable, porous materials at a greater rate than the anticipated replenishment, and eventually the supply from this source will dwindle. Also, the foothill regions are developing water uses and unless a surface source of water supply is made available to them, the consumptive use in the foothill regions of water obtained from wells is expected to exceed the replenishment of the underlying ground water basin. Consequently, no appreciable supply from the foothill region by underground flow into the Calaveras Unit seems advisable to contemplate in the determination of more than the immediate future water supply for the Calaveras Unit.

Summing up the conditions outlined in the next preceding numbered paragraphs, it appears probable that most of the ''subsurface inflow'' into the Calaveras Unit, given in Table 19, major corrections, p. 9, as 35,500 acre-feet per year, will be progressively lost under the future land use anticipated in the region of concern.

The basic measurements and estimates used to determine the 33,500 acre-feet of subsurface inflow into the Calaveras Unit are considered subject to usual limits of accuracy for such measured and estimated quantities. Unfortunately, small percentage differences in the measured and estimated quantities used in the bulletin for computing the underground inflow will result in large variations in the quantity determined.

For example:

Summarized, the sources of "safe ground water yield" for the "Calaveras Unit," as determined by the data and methods set forth in major corrections, pp. 2 and 3, Table 9; p. 6, Table 17; p. 9, Table 19, are as follows:

(All quantities in acre-feet per season)

SURFACE INFLOW (Table 19)		172,700
Sources:		
Calaveras River (Table 9)		167,500
Balance is "minor drainage"		5,200
* * * * *		
SURFACE OUTFLOW (Table 19)		137,500
Adjustment for "present conditions" (footnote "c", p. 9, major corrections)		13,400
Total outflow for "base period"		150,900
Sources:		
Calaveras River (Table 9)	2,100	
Stockton Diverting Canal (Table 9)	148,800	
Total—Calaveras River and Diverting Canal		150,900
Indicated "unmeasured outflow"		none
SURFACE INFLOW MINUS SURFACE OUTFLOW (from above)		
Calaveras River inflow	167,500	
Calaveras River plus diverting canal outflow	150,900	
Calaveras River, Morman Slough and Stockton Diverting Canal loss and use in Calaveras Unit		16,600
"Minor drainage" inflow	5,200	
Indicated "unmeasured outflow"	none	
Total loss and use of "minor drainage" in Calaveras unit		5,200
Excess of surface inflow over surface outflow for "base period"		21,800
Adjustment for "present conditions"		13,400
Excess of surface inflow over surface outflow for "present conditions"		35,200
PRECIPITATION (Table 19)		
Base period average	112,000	
Consumptive use, "present conditions"	93,300	
Indicated percolation to underlying ground water basin		18,700
UNDERGROUND INFLOW (Table 19)		35,500
TOTAL SUPPLY FOR SURFACE AND UNDERGROUND LOSSES AND USES IN UNIT		89,400
"Mean consumptive use" of "Applied surface water" under "present conditions" (Table 19)		9,300
Balance "safe ground water yield" (same as determined in Table 19)		80,100

* * * * *

Without allowances for surface diversions, evaporation and transpiration from any of the surface sources of supply and without allowances for the runoff of precipitation from the City of Stockton which results from storm drains discharging into the tidewater areas west of Stockton, and using only the exact data and methods employed for the periods considered in the bulletin and the Major Corrections estimates, the sources of the "safe ground water yield" are as follows:

SOURCE OF SAFE GROUND WATER YIELD	*Gross amount of loss and use in unit*
Calaveras River	16,600 acre-feet
Precipitation (within unit)	18,700
Underground inflow	35,500
"Minor drainage"	5,200
Total	76,000

Taking the Calaveras River as an example:	
Gross loss and use	16,600
Allowance for "base period" evaporation, transpiration and diversions from Bellota to tidewater—say	5,000
Indicated magnitude of percolation	11,600
Say—12,000 acre-feet per year	

* * * * *

For "minor drainage":
Gross loss and use is 5,200 acre-feet

No allowance is evidenced in the bulletin determination for any "unmeasured outflow" from the Calaveras Unit, although such outflow from minor natural drainage-ways is known to exist. Certainly a portion of this "minor drainage" inflow is lost through surface evaporation and transpiration, as well as from surface outflow. Any appreciable contribution of such gross loss and use toward the replenishment of storage in the underlying ground water reservoir would, of necessity, be a very small quantity.

For "precipitation":
Gross loss and use (other than direct "consumptive use") 18,700 acre-feet

The disposition of rainfall occurring on and considered applicable to the lands within the Calaveras Unit is outlined on pp. 3 and 6, supra. The actual contributions of rain falling on the lands within the unit to the safe ground water yield for the reasons previously stated are considered to be negligible to nonexistent in any appreciable quantity in years of below normal rainfall, and of sufficiently small magnitude in other years to eliminate any reliance thereupon as a source of any appreciable contribution to the underground water supply.

Although the district's engineering investigation of the relative quantities of replenishment to the ground water reservoir underlying the Calaveras Unit is not complete, Table VI following indicates the relative and general magnitude of the amount of replenishment considered probable as attributable to the principal factors supplying the underground reservoir.

TABLE VI

APPROXIMATE MAGNITUDE OF AVERAGE ANNUAL UNDERGROUND WATER BASIN REPLENISHMENT FACTORS FOR CALAVERAS UNIT

Contributing source	*Acre-feet*	*Percent total*
Percolation from:		
Calaveras River inflow	26,000*	32%
Other surface inflow	4,000*	5%
Total from inflow	30,000	37%
Rainfall	†	†
Subsurface inflow	50,000‡	63%
Total replenishment	80,000	100%

* Includes percolation resulting from surface inflow diverted for irrigation, as prevailed in 1954, and small increment of direct rainfall penetration, both of which serve to replenish the underground water supply.

† Rainfall is considered primarily consumed by evaporation and transpiration within unit. All except a small portion of the balance is considered as exported from the area by natural and artificial drainage. The small portion contributing to underground water basin replenishment is included as an increment of the percolation from surface inflow.

‡ Under 1954 underground water surface conditions in Calaveras Unit and adjoining areas.

* * * * *

All factors influencing the replenishment of the underground water reservoir underlying the Calaveras Unit are factors of vital importance to the Stockton and East San Joaquin Water Conservation District. Of particular importance is the amount contributed by "subsurface inflow," inasmuch as the control thereof is outside the conservation district's jurisdiction. The major sources of "subsurface inflow" are subject to reduction and loss as hereinbefore set forth (pp. 13 and 16) and in the following described manner:

Based upon the recent behavior of the underground water surface in the Calaveras Unit with respect to that within the adjoining Eastern Mokelumne and Littlejohns Units, as portrayed on Plate 12, and particularly on Plates 9 and 11 of the bulletin, and also based upon the anticipated growth and development within the units, it is considered not at all improbable that in the future the relative elevations of the underlying ground water surfaces within the respective units may change so that a net outflow of appreciable concern will occur from the Calaveras Unit into both the Eastern Mokelumne and Littlejohns Units.

Cognizance must be taken that the future contributions to the Calaveras Unit underground water basin which can be expected from underground inflow accruing from the Western Mokelumne Unit must be expected to decline due to both the present and increasing urban development of the Stockton metropolitan area within the Western Mokelumne Unit, and the decreasing contribution to the underground water basin from the operations of the Woodbridge Irrigation District resulting both from the development of additional consumptive use requirements within the Western Mokelumne Unit and the decrease in supply available to the Woodbridge Irrigation District from the Mokelumne River, due to the increasing upstream diversions under presently issued permits.

The relatively minor contributions from both San Joaquin River Delta area to the west is not a desirable source of underground water supply, and the elimination thereof insofar as practicable by the refilling of the underground water sink under Stockton should be accomplished as soon as practicable.

The future underground inflow that can be expected from the foothill region to the east will also decrease due to the development of the consumptive use within that region, as well as the progressive draining of the underlying ground water storage.

In the future, it is possible (if not probable) the underground outflow from the Calaveras Unit will exceed the underground inflow, and water will be lost to the unit through the medium presently thougnt to supply about 63 percent of the replenishment to the underlying ground water basin.

To the extent that the net underground inflow decreases or becomes outflow, the safe yield of the underground water basin will be decreased, and additional supplemental supply will be required for the Calaveras Unit. The 50,000 acre-feet per season approximation of net contribution of underground inflow set forth in Table VI (comparable to the 35,500 acre-feet per season set forth in the major corrections—Table 19) is by no means the limit of the possible decrease in the safe ground water yield which may be occasioned by reasonably anticipated future developments within the region of concern.

It is believed necessary to fully recognize the potential decrease in the future safe ground water yield, in determining the supplemental water supply required both for the Calaveras Unit, and particularly for the Stockton and East San Joaquin Water Conservation District, together with those lands within the Calaveras and Littlejohns Units which are now and will be embraced within the Stockton metropolitan area.

* * * * *

IV. SUPPLEMENTAL WATER REQUIREMENTS

(Ref. Major Corrections, p. 20, Table 41)

Table 41 gives the "present supplemental water requirement" and "probable ultimate mean supplemental water requirements" for the Calaveras Unit, as set forth in Table VII following. Also set forth in Table VII are the differences resulting from the district's estimates of "consumptive use" of water, as hereinbefore set forth in Table IV, p. 176, and also allowances for the effect of urban development of metropolitan Stockton within both the Western Mokelumne Unit and the Littlejohns Unit and the ultimate decrease in the ground water yield have been added thereto. The respective sums thereof, for present and ultimate conditions, the totals of Table VII following, are considered representative of the present supplemental water requirement of the Calaveras Unit and the ultimate supplemental water requirement for the Calaveras Unit together with that portion of metropolitan Stockton expected to develop within the Western Mokelumne and Littlejohns Units—both of which are of concern to the Stockton and East San Joaquin Water Conservation District.

TABLE VII

ESTIMATED PRESENT AND PROBABLE ULTIMATE SUPPLEMENTAL WATER REQUIREMENTS FOR CALAVERAS UNIT AND ADJOINING STOCKTON METROPOLITAN DEVELOPED URBAN AREA

	Average annual supplemental requirement in acre-feet	
	Present	*Ultimate*
From major corrections (p. 20, Table 41)	18,400 (1951-1952)	51,800
Increase for difference in estimates for Calaveras Unit *only* (from Table IV, p. 176)	31,247 (1955)	52,451
Total for Calaveras Unit without consideration of the effect of probable developments outside the unit	49,647	104,251
ADD		
For ultimate Stockton urban development outside the Calaveras Unit (p. 15)		53,302
For ultimate decrease in present safe ground water yield (pp. 27-29)		33,000*
Total for Calaveras Unit and outside Stockton urban development		190,553

* An allowance predicated on assumptions of future developments which are primarily dependent upon factors outside the control of the Stockton and East San Joaquin Water Conservation District. The actual quantity could vary appreciably in either direction.

* * * * *

In order to provide a water supply for the Stockton and East San Joaquin Water Conservation District adequate to assure the full potential economic development, both of metropolitan Stockton and the supporting rural and other urban areas expected to develop within the present limits of the conservation district, it is believed necessary to progressively provide from about 55,000 acre-feet per annum in the near future and an ultimate supplemental water supply in the order of 200,000 acre-feet per annum.

* * * * *

V. PLANS FOR INITIAL LOCAL DEVELOPMENT

Cognizance is taken in Table 19 of the effect of the Stockton and East San Joaquin Water Conservation District's operations on the Calaveras River under contracts with the Linden Irrigation District and the City of Stockton, as outlined in the bulletin, pp. 3-9 and 3-16. The advantages to the Calaveras Unit in terms of supplemental water supply are indicated by

(i) Footnote "c" to Table 19 (p. 9, Major Corrections), which states:

"c—Base period average surface outflow reduced by 13,400 acre-feet under present conditions, 12,000 acre-feet new retention in unit due to operation of Hogan Dam, and 1,400 acre-feet due to increased surface diversions from Mormon Slough."

(ii) The next to the last paragraph on p. 3-9 of the Bulletin, particularly the last sentence thereof, which states:

"During the period from 1948-49 through 1951-52, a total of approximately 60,000 acre-feet of Calaveras River waters was retained by these two measures, over and above that amount which normally would have been retained."

The " * * * two measures * * *" referred to in the preceding sentence are:

(a) Control works leased from the Linden Irrigation District which are used to apportion the flow between the Calaveras River and Mormon Slough near Bellota, and

(b) Storage of Calaveras River water in Hogan Reservoir during the latter part of the natural runoff season (to the extent same will not impair Hogan Dam's prime purpose of flood protection) and subsequent release of water so stored for surface irrigation use and augmenting percolation from the Calaveras River and Mormon Slough.

The effect of the above-mentioned operations is appreciable, both for the entire Calaveras Unit and particularly for the portion thereof east of Stockton. The estimated "* * * 60,000 acre-feet of Calaveras River waters * * * retained * * * over and above that amount which normally would have been retained" within the Calaveras Unit during the period from 1948-49 through 1951-52 represents a volume of about 983,600 acre-feet of storage space in the underlying ground water reservoir. (Based upon 6.1% "Weighted average specific yield * * *," for Calaveras Unit—Major Corrections, p. 5, Table 16.) Predicated upon the 85,970 acres within the Calaveras Unit this represents an average decrease in the actual lowering of the underground water surface of about 11.44 feet over that which would have been experienced during the period from 1948-49 through 1951-52 without the district's operation. This is a significant quantity.

The district's operations from 1948-49 through 1951-52 has partially arrested the decline of the underground water basin by

(i) Decreasing the draft on the underground water basin resulting from substitution of surface for well water supply for irrigation, and

(ii) Increasing the underground water replenishment, both that

(a) Occurring from increased stream bed percolation, and that

(b) Resulting from use of surface water for irrigation with the accompanying percolation of a portion thereof into the underlying ground water reservoir.

Although such effect was not uniform over the entire area, it represents a material saving in power required for irrigation and other pumping from wells within a large portion of the conservation district.

* * * * *

Plans under consideration by Stockton and East San Joaquin Water Conservation District

The works and operations which will adequately and economically fulfill the future water requirements of the Stockton and East San Joaquin Water Conservation District are believed to be those which will

A. Increase the use of water from surface sources for irrigation purposes, and thus
   (i) Decrease the future draft which will otherwise occur upon the underlying ground water reservoir from use of well water for irrigation purposes, and
   (ii) Increase the replenishment of the underground water reservoir by percolation of that portion of the irrigation water obtained from surface sources which will accrue to the underground water basin under normal irrigation practices, and

B. Increase the percolation from the Calaveras River and its distributaries either through
   (i) Increasing the time water either from natural flow or other sources is available in the channels, or
   (ii) Artificial works which will tend to increase percolation from the channels, and possibly

C. Replenish the underground water reservoir by use of either supplemental irrigation of agricultural land, or broad irrigation of ground water recharging basins within the relatively permeable areas.

In conjunction with the above works, it is contemplated to utilize the storage available in the underlying ground water reservoir, both that above and below the present underground water surface, to provide at least a major portion of the cyclic storage required to augment the supply of water available in periods of below normal precipitation and surface water supply, as well as to store water during the runoff periods for use during the irrigation season.

The general prime sources of supplemental water supply listed in the presently considered order of probable development are:

1. Calaveras River, from runoff pursuant to Applications Nos. 12668 and 12839.
2. Calaveras River, from runoff and back water from San Joaquin River delta sources, pursuant to Applications Nos. 13423 and 13424.
3. American River, through Folsom South Canal, either by contract with the Bureau of Reclamation or pursuant to Applications Nos. 16385 and 16386.
4. Calaveras River, through *New Hogan Project* (Bulletin—p. 4-95 and following).
5. Possibly the New Melones Project, Major Corrections, p. 32 and following.

Presently available engineering and cost information is not sufficient to provide either assurance that the above order will prevail, or even rough estimates of the respective quantities to be obtained from each source which will be utilized to the best economic advantage for fulfilling the anticipated progressively increasing and ultimate supplemental water requirements necessary to provide for the full economic growth and development of metropolitan Stockton and the Stockton and East San Joaquin Water Conservation District.

Present opinion is that, while of interest to the Stockton and East San Joaquin Water Conservation District, neither the *Delta-Stockton Diversion Project*, outlined in the Bulletin, p. 4-88 and following, nor the *New Melones Project*, outlined in the Major Corrections, p. 32 and following, will afford the most economic supply for the area of concern. However, if either of them or similar waterworks facilities are either constructed or employed by those directly concerned with water supply for the Stockton metropolitan region, account thereof will be taken in the reduction of the otherwise required supplemental water supply.

Respectfully submitted,

STOCKTON AND EAST SAN JOAQUIN
WATER CONSERVATION DISTRICT
BY IRVING L. NEUMILLER,
Attorney and Secretary

TUOLUMNE COUNTY WATER DISTRICT NO. 2

H. C. HOLMAN, Consulting Civil Engineer
STOCKTON, CALIFORNIA, October 28, 1955

MR. A. D. EDMONSTON, State Engineer
Secretary, State Water Resources Board
Public Works Building
Sacramento 5, California

Subject: Bulletin No. 11

DEAR MR. EDMONSTON: As directed by the Board of Directors of the Tuolumne County Water District No. 2, I have prepared a report on the ultimate water requirements of the district from studies that have been made by them.

A copy of this report is attached.

Thank you for this opportunity to comment on Bulletin No. 11.

Yours very truly,

H. C. HOLMAN

COMMENTS ON THE PRELIMINARY DRAFT AND REVISIONS TO THE STATE OF CALIFORNIA WATER RESOURCES BOARD BULLETIN NO. 11

TUOLUMNE COUNTY WATER DISTRICT NO. 2

October 19, 1955

MR. A. D. EDMONSTON, Secretary
State Water Resources Board

DEAR MR. EDMONSTON: Thank you for the opportunity to comment on the revisions of the preliminary draft of Bulletin No. 11 "San Joaquin County Investigations." We are particularly anxious to have included in the bulletin a statement regarding the ultimate water requirements of Tuolumne County. The engineer for this district, Mr. H. C. Holman has been instructed to prepare such a statement and forward it to you.

Action of the board of directors of this district was as follows: "It was moved by Director Sylva, seconded by Director Kerr and carried that the engineer be directed to prepare comments on the preliminary draft and proposed revisions of Bulletin No. 11 "San Joaquin County Investigations," and that such comments be forwarded to the State Board of Water Resources."

Sincerely yours,
(Signed) HARRY S. HINKLEY

COMMENTS ON THE PRELIMINARY DRAFT AND REVISIONS TO THE STATE OF CALIFORNIA WATER RESOURCES BOARD BULLETIN NO. 11

The Stanislaus River and especially the South Fork of the Stanislaus is of vital importance to the development of Tuolumne County. In recognition of this fact the Tuolumne County Water District No. 2 has made extensive investigations and studies of the future water requirements for the lands within their district and of the possible sources of obtaining and storing this needed water.

Since 1948 the district has made numerous filing on the Stanislaus and Tuolumne Rivers and their tributaries which with the filings of the Department of Finance should provide the necessary water for the development of their lands.

In 1949 the district employed Roy E. Fredricksen to make a detailed study of the potential irrigable lands within the district and county. A copy of the report on this study is attached as Exhibit A.

In 1951 the district employed George Hutchinson, Soil Specialist of Oakland to review Mr. Fredricksen's study. The conclusions of his report are attached as Exhibit B. A copy of his entire report is on file with the Division of Water Resources.

Mr. Fredricksen's report shows a net irrigable acreage of 46,040 acres. Mr. Hutchinson in his report reasonably substantiates this as acreage which could ultimately be developed.

The Division of Water Resources in its report on the "Water Resources of the Stanislaus River" dated, June 1951 gives the following gross water requirements for the net irrigable area in Tuolumne County.

TABLE 9—PAGE 53

Net irrigable area 80 percent of gross	4.6 acre-feet/acre
Net irrigable area 50 percent of gross	4.7 acre-feet/acre

Using the lower of these two gross water requirements or 4.6 acre-feet/acre and Mr. Fredricksen's net irrigable area of 46,040 acres, the ultimate potential water requirement within the district would be 211,784 acre-feet.

Bulletin No. 11 on page 4-25, only allows 77,000 acre-feet and on page 4-117 only 81,000 acre-feet of the total flow of the Stanislaus River for use within the district area.

CONCLUSION

There is a difference of 130,784 acre-feet between the ultimate requirements as shown by studies made by the Tuolumne County Water District No. 2 and those shown in Bulletin No. 11. This difference should be seriously considered before the water is alloted to other areas outside the County of Origin.

(Signed) H. C. HOLMAN, Engineer
Tuolumne County
Water District No. 2

October 28, 1955

EXHIBIT A
REPORT OF IRRIGABLE LAND SURVEY OF TUOLUMNE COUNTY WATER DISTRICT NO. 2

By ROY E. FREDRICKSEN, Civil Engineer

May 1, 1951

In the fall of 1949 I was requested by the Board of Directors of Tuolumne County Water District No. 2 to make a survey of the lands of the District as to their suitability for irrigation. The field examination was made during November and December, 1950, followed by office computations to determine the acreages. The field work was made with the use of an army jeep and by foot in inaccessable areas. During the field inspection I was often accompanied by members of the board, by Mr. Harry Hinkley, Farm Advisor for the County of Tuolumne, and by numerous ranchers and orchardists securing their opinions of the possibilities of irrigating the various lands of the District. Some of the ranchers were L. B. Woodham, James Scott, C. Q. Fitch, Louis Kress, Clarence Winn, Tom Harmon, Carl K. Williams, Albert and Gus Falk and Frank Williams.

The field mapping was done on U. S. G. S. Quadrangle sheets of the latest edition. A brief discussion is given of the soil conditions and mapping problems encountered.

1. *Merced Falls, Cooperstown, Copperopolis and Chinese Camp Sheets.*

In this area, also known as the Keystone area, the soil is somewhat shallow and has numerous rock outcroppings. It is largely a rolling type of ground although it does have extensive level area.

2. *Sonora and Columbia Sheets.*

Here the soil was deeper, but the slopes were also steeper. Much brush-covered land was included.

3. *Standard, Columbia S. E. and Tuolumne Sheets.*

Here the soil in general was quite deep and the mapping consisted largely in mapping out areas of favorable topography. Most of the county's irrigated apple orchards are in this area.

4. *Groveland, Jawbone and Moccasin Sheets.*

This area is not in the district although it is in the County of Tuolumne. Here the soil was very deep and the mapping consisted almost entirely in mapping out areas of favorable topography.

Measurement of the irrigable area from the quadrangle sheets was made with a planimeter. The sheets had been first marked with the results of the State Division of Water Resources survey titled, "Land Classification Standards and Criteria, Survey of Mountainous Areas, Calaveras and Tuolumne Counties," with which I agreed as being irrigable, and then my areas were added. The following is a summary indicating acreage in addition to the State's findings.

Sheet	*Inside T. C. W. D. No. 2 acres*	*County of Tuolumne, acres*
Merced Falls	7,454	10,327
Cooperstown	1,374	1,374
Copperopolis	13,974	13,974
Chinese Camp	14,693	14,693
Sonora	6,632	6,632
Columbia	1,616	1,616
Standard	9,926	9,926
Columbia S. E.	2,708	2,708
Tuolumne	5,012	5,012
Twain Harte Area	313	313
Groveland	---	19,675
Jawbone	--	2,208
Moccasin	327	2,673
Total	64,029	91,131

The State's survey reported a total gross irrigable land area of 51,110 acres in the County and 37,057 acres in the District and after application of percentage factors to eliminate the area occupied by highways, railroad, ditches, farm improvements, stream beds and minor areas which would not be irrigable, their net area was 27,324 acres in the County and 20,428 acres in the District. This is a reduction of approximately 50%. Considering that the best lands were included in the State's survey, a reduction of 60% should be used in determining the additional net acreage found by this survey resulting in 25,612 acres within the District and 36,452 acres within the County as a whole. Totaling my figures with the State's figures gives 46,040 acres in the District and 63,776 acres in the County.

As a summary it is felt that the state's survey was not inclusive enough in their work. It was found during the field examination that they confined their findings to areas near roads indicating that my use of the jeep enabled better coverage, that they confined their findings to cultivated and presently irrigated areas, that large areas where good high brush was growing were not included even though adjacent and similar ground was included, and that many steep areas capable of being irrigated were omitted.

(Signed) Roy E. Fredricksen, C. E.-7336

EXHIBIT B
CONCLUSIONS OF REPORT TO TUOLUMNE COUNTY WATER DISTRICT NO. 2

By George Hutchinson, Soil Specialist
600 Sixteenth St., Oakland 12, California

Conclusions

After a review of the Reports of Survey conducted by the State Division of Water Resources and the Tuolumne Water District No. 2, and familiarizing myself with the area covered by spot check investigation, I have come to the following conclusions concerning the Report of the State Division of Water Resources:

1. Too much emphasis was given to topographic features or slopes in view of the development of irrigated pasture land under modern sprinkler irrigation.

2. Coverage was not detailed sufficiently in areas not accessible to roads and the elimination of brush covered areas appears is not justified with the help that is now available in conducting controlled burning.

3. Cost of clearing land and installation of portable sprinkler irrigation system not given sufficient emphasis in the determination of suitable areas for irrigated agriculture.

4. Too much emphasis placed on irrigated tree and row crops and insufficient to irrigated pasture use. An 80 percent penalty on these lands does not appear justified in light of their potential possibilities.

5. Technical rating of the soils and decision based thereon rather than on native vegetation type and growth does not seem entirely justified.

6. The report appears to be a conscientous attempt to evaluate the areas, but the approach was apparently more from the technical rather than from the practical point of view.

7. Although the Fredricksen Report probably includes some questionable acres of land, I believe it is considerably less in amount than the Report of the

State Division of Water Resources failed to include because of their lack of appreciation of progress in bringing the steeper lands under irrigation through employing modern and well established methods of water application.

8. It is quite well established that the steeper lands, having adequate surface and subsurface drainage, will produce more and better crops over a longer period than will the flat lands where the conventional methods of irrigation are still in use. This is due largely to the high ground water and alkali difficulties that are eventually encountered on the flat lands and can only be corrected by installation of expensive artificial drainage systems, accompanied ofttimes with involved soil treatments, to re-establish proper drainage and to rehabilitate the soils.

WOODBRIDGE IRRIGATION DISTRICT

Law Offices
Jones, Lane, Weaver & Daley
Stockton, California, October 28, 1955

Mr. A. D. Edmonston, State Engineer
Division of Water Resources,
Sacramento, California

Re: Bulletin 11

Dear Mr. Edmonston: The Woodbridge Irrigation District takes advantage of the opportunity offered by you to present its comments on the final draft of Bulletin 11, the report of the San Joaquin County Water Investigation.

We first want to express our appreciation of the work done, an investigation of such varied interests and problems, and of so many and conflicting claims. To be as completely factual and disinterested, except to show the facts, is something that some times is hard to do. We feel you have done that.

The comment we desire to make is the result of considering and relating the pending applications for appropriation of water from the Mokelumne River, to the facts shown in Bulletin 11.

The bulletin describes and outlines an area designated the Western Mokelumne Unit, which is bounded in the west by the Delta, on the north by the Mokelumne River, on the east by a line running generally from the west side of the City of Lodi to the point where the Central California Traction Company lines cross the diverting canal, and on the south by the diverting canal—Plate 2. This is the area that is now either being served with irrigation by Woodbridge Irrigation District or that can be served with very slight expense for enlarging and extending the existing canals. This Western Unit contains a total of 73,470 acres. Woodbridge Irrigation District has served as much as 17,000 acres in one year, but has served over the past ten years many thousand acres in addition, as many farmers require water one year but not in another year. If Woodbridge Irrigation District were assured of having a safe supply it could supply water ultimately to the entire 73,470 acres. Incidentally it is well to note that the lands in that unit fall within the top 3 land classes, 31,600 acres in Class 1, 22,510 acres in Class 2, and 17,550 acres in Class 3. Only 220 acres are in lower classes. See Table 11.

The bulletin shows that from 1942-43 to 1950-51 Woodbridge Irrigation District has diverted an average of over 109,000 acre-feet per year, in 1949-50, 147,500 acre-feet. See Table 26.

The probable ultimate needs of the Western Mokelumne Unit are shown in the bulletin as 226,600 acre-feet. See Table 37.

To the east of and contiguous with this unit is another described and designated as Eastern Mokelumne Unit, which is approximately 8 miles wide east and west, and 10 miles long north and south, extending on both sides of the river west of Lockeford. Plate 2. This unit comprises 110,800 acres. This district is not yet served by an organized or community irrigation system, yet it is dependent on the Mokelumne River for its irrigation water supply, either directly by direct surface diversion, or from wells draining water from the underground which is fed by the river.

The bulletin shows that the ultimate needs of the Eastern Mokelumne Unit to be 317,300 acre-feet. See Table 37.

East Bay Public Utility District, hereafter referred to as East Bay, then a district comprising 93 square miles, constructed Pardee Dam on the Mokelumne River near Valley Springs, pursuant to certain permits granted to it in the late 1920's.

Permit No. 2459 allows an appropriation for municipal purposes of 310 cubic feet per second by direct diversion the year round and 217,000 acre-feet per annum by storage between October 1st of each year and July 15th of the succeeding year (the combined diversion and storage not to exceed 200,000,000 gallons per day). East Bay used only 119,000 acre-feet in 1954.

License 1388 allows for power purposes a right to 375 c.f.s. by direct diversion year round and 198,965 acre-feet per annum by storage between January 1st and July 31st of each year.

Permit 3587 allows for power the same diversion as License 1388 but extends the storage period to include the time October 1st to December 31st of each year.

Both of the above permits and license contain a condition in substantially the following language:

"As there is a possibility that there will not be sufficient water in Mokelumne River during the latter part of the irrigation season to satisfy all requirements, this license is issued subject to the express condition that the use hereunder may be regulated by the Division of Water Resources during such periods of water scarcity to the end that such use will not interfere with rights under prior applications."

Permit 2459 (municipal use) contains in addition the following condition:

"The amount of water appropriated shall be limited to the amount which can be beneficially used and shall not exceed 310 cubic feet per second for direct diversion from January 1st to December 31st of each season and 217,000 acre-feet per annum for storage to be collected from about October 1st to about July 15th of each season when there is unappropriated water available at the proposed point of diversion, the season of unappropriated water being in years of normal flow from about December 1st to about July 15th, provided however that combined diversions from natural flow and storage shall not exceed the equivalent of 310 cubic feet per second or approximately 200,000,000 gallons per day."

"No water shall be diverted under this permit for other than municipal purposes within the boundaries of the East Bay Municipal Utility District."

The general result then is that East Bay is not permitted to store waters in Pardee Dam during the season when irrigation water is needed downstream and that if downstream irrigation needs require it, the Division of Water Resources may step in and regulate East Bay's handling of the water.

The actual experience over the past years since East Bay commenced their operation discloses a distinct and complete violation of the conditions imposed, at least in principle.

This came about in the following manner. Pacific Gas & Electric stores for power purposes above Pardee and releases through its power plants after the natural run off diminishes 190,000 acre-feet. Ordinarily by July 1st of each year East Bay has stored in Pardee Dam in excess of 200,000 acre-feet. The P. G. & E. releases an average of between 550 and 575 c.f.s. through the summer, the irrigation season. This water does not come through Pardee Dam. Only a much smaller amount is released so that East Bay at the end of the irrigation season, about September 1st to 15th holds in Pardee Dam about 200,000 acre-feet. After the irrigation season is over it releases water for power purposes, much of the time at a rate higher than in the irrigation season. No irrigation need then being present the water flows down the river and into the sea. At this writing it holds over 180,000 acre-feet and is still releasing for power.

East Bay would probably contend that this storage was under their municipal use permit, because the needs for irrigation downstream were, this year, definitely not satisfied. But if stored for municipal use as a safeguard against an ensuing dry year the storage would be held until it was certain that there would be an adequate run off next season. East Bay does not and can not now have that knowledge. The facts prove that the water stored was not for municipal use but to obtain the revenue from power.

Municipal use, it is true, is the highest use of water, but irrigation needs come ahead of power, so that when East Bay deprives the irrigators below of the water they need and then uses it for power when the irrigators below do not need it, that is we contend a violation of the principle of the conditions imposed upon them if not the express terms of the conditions.

East Bay has annually as yet used approximately but one-half of the amounts granted for municipal use and their officers testified that they would not exhaust the present allowance until 1990 or thereafter. They now seek under a pending application to enlarge their rights, based not on 40 years or 100 years hence, but upon what they say (peering into the crystal ball) to be their ultimate need not only for the existing sized district, but for an enlarged district of over 400 square miles.

East Bay claims 310 c.f.s. continuous flow would produce approximately 224,000 acre-feet for municipal purposes under its present permit, and seeks in addition 273,000 acre-feet.

Amador Canal and Calaveras Public Utility together have a right to take water in excess of 12,000 acre-feet.

East Bay estimates the channel losses (in seepage and evaporation, etc.) below Pardee at 24,300 acre-feet.

What is the total:

East Bay present permit	224,000 acre-feet
East Bay application	273,000 acre-feet
Amador and Calaveras	12,000 acre-feet
Channel losses	24,300 acre-feet
Western Mokelumne Unit	226,600 acre-feet
Eastern Mokelumne Unit	317,300 acre-feet
	1,077,200 acre-feet

The Mokelumne River has an average seasonal flow of about 780,000 acre-feet as shown by the records from 1894-95 through 1946-47. See Table 6. It is thus demonstrated that when ultimate needs are to be considered there is not enough water in the Mokelumne to satisfy them.

All of this leads us to the ultimate comment we want to make. While municipal use is, according to our law, the highest use, irrigation is second, and power third. Therefore it would seem that one definite and positive rule should be established, i.e., that no water shall be used for power purposes after the close of the irrigation season, that upon release run unused to the sea, except only after the needs for irrigation below have been satisfied.

Respectfully submitted,

WOODBRIDGE IRRIGATION DISTRICT
By JONES, LANE, WEAVER & DALEY
By GILBERT L. JONES,
Attorneys for Woodbridge Irrigation District

APPENDIX C

RECORDS OF MONTHLY PRECIPITATION IN SAN JOAQUIN AREA NOT PREVIOUSLY PUBLISHED

TABLE OF CONTENTS

RECORD OF MONTHLY PRECIPITATION AT IONE, CALIFORNIA

County: Amador
Date established: 1878
Elevation: 287 feet, U. S. G. S. datum

Station number on Plate 3: 5-141
Location: SW ¼, Sec. 24, T. 6 N., R. 9 E., M. D. B. & M.
Record obtained from: Southern Pacific Railroad; East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1929-30	0.00	0.00	0.00	0.00	0.00	2.91	5.62	3.02	3.40	1.58	0.54	0.00	17.07
30-31	0.00	0.00	0.00	0.00	2.00	0.13	3.92	2.47	1.78	0.42	1.26	0.64	12.62
31-32	0.00	0.00	0.00	0.95	3.45	6.20	2.18	4.80	0.70	1.43	0.28	0.00	19.99
32-33	0.00	0.00	0.00	0.00	0.60	2.40	4.22	1.40	2.70	0.00	1.45	0.00	12.77
33-34	0.00	0.00	0.00	1.80	0.00	7.10	2.35	4.21	0.00	0.00	1.70	0.70	17.86
1934-35	0.00	0.00	0.00	1.30	4.40	3.28	3.94	1.25	3.43	6.34	0.00	0.00	23.94
35-36	0.00	0.00	0.00	1.70	1.25	3.20	6.11	13.28	0.75	0.75	1.20	0.80	28.29
36-37	0.00	0.00	0.00	0.93	6.85	3.84	5.22	6.90	9.50	1.55	0.00	0.20	34.99
37-38	0.00	0.00	0.00	0.80	2.60	2.30	4.35	8.80	5.65	1.65	0.35	0.00	26.50
38-39	0.00	0.00	0.00	1.66	1.89	0.15	2.83	1.72	3.42	2.13	0.00	0.00	14.05
1939-40	0.00	0.00	0.55	0.85	0.10	1.42	8.87	7.50	5.08	0.48	0.00	0.00	24.85
40-41	0.00	0.00	0.00	0.73	0.44	5.91	5.68	3.95	3.29	4.62	0.55	N.R.	25.17
41-42	N.R.	N R.	N.R.	0.48	1.61	5.96	6.30	3.28	2.29	4.28	2.47	N.R.	26.67
42-43	N.R.	N.R.	*0.08	0.35	4.70	3.07	5.96	2.87	8.02	2.33	0.06	0.25	27.69
43-44	0.00	0.00	0.00	0.34	1.01	2.12	3.21	6.87	1.52	3.09	1.00	0.09	19.25
1944-45	0.00	0.00	0.40	1.78	5.95	2.17	0.78	5.71	3.92	1.25	0.62	1.13	23.71
45-46	0.00	0.00	0.00	2.86	3.14	6.67	0.89	1.85	3.25	0.15	1.33	0.00	20.24
46-47	0.00	0.00	0.26	0.95	4.13	1.92	0.88	1.50	2.95	1.44	0.10	0.41	14.54
47-48	0.00	0.00	0.00	3.16	1.85	1.15	0.96	1.96	4.30	4.29	2.57	0.00	20.33
48-49	0.00	0.00	T	1.17	0.86	3.85	2.31	2.51	6.03	0.00	0.50	0.00	17.23
1949-50	0.00	0.11	0.00	0.05	2.23	0.89	6.82	2.85	3.35	1.48	0.43	0.09	18.30
50-51	0.00	0.00	0.00	2.50	6.41	6.10	6.12	3.09	1.97	1.45	1.12	0.00	28.76
51-52	0.00	0.00	0.00	1.75	2.77	6.15	6.96	2.66	5.19	1.36	0.21	0.00	27.05

* Estimated. N.R.—No Record. T—Trace.

RECORD OF MONTHLY PRECIPITATION AT GALT, CALIFORNIA

County: Sacramento
Date established: 1937
Elevation: 45 feet, U. S. G. S. datum

Station number on Plate 3: 5-150
Location: SE ¼, Sec. 27, T. 5 N., R. 6 E., M. D. B. & M.
Record obtained from: East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1937-38	N.R.	N.R.	N.R.	0.54	2.32	3.37	2.38	7.96	5.85	1.28	0.22	0.00	23.42
38-39	0.00	0.00	0.11	1.43	0.75	0.63	2.33	1.53	2.61	0.35	1.82	0.00	11.54
39-40	0.00	0.00	0.55	0.67	0.21	1.39	7.53	6.11	3.62	0.75	0.37	0.00	21.20
40-41	0.00	0.00	0.05	0.72	0.30	8.04	4.14	4.24	2.52	3.85	0.71	N.R.	24.57
41-42	N.R.	N.R.	N.R.	0.80	1.45	5.39	4.71	2.68	2.51	4.23	1.93	0.00	23.70
1942-43	0.00	0.00	0.40	0.40	3.47	2.35	4.67	2.27	5.85	1.80	0.40	0.00	21.61
43-44	0.00	0.00	0.00	0.21	0.94	1.74	2.56	5.98	0.97	1.07	0.71	0.00	14.18
44-45	0.00	0.00	0.01	1.22	2.40	3.32	0.15	4.03	2.78	0.15	0.28	0.26	14.60
45-46	0.00	0.00	0.00	1.92	1.52	5.14	0.52	0.99	2.43	0.00	0.58	0.00	13.10
46-47	0.00	0.00	0.09	0.70	3.44	1.52	0.48	1.78	2.36	0.17	0.14	0.34	11.02
1947-48	0.00	0.00	0.08	2.16	1.04	0.82	0.65	1.17	3.21	2.47	1.84	0.00	13.44
48-49	0.00	0.00	0.00	0.93	0.69	3.78	1.82	1.95	4.30	0.00	0.45	0.00	13.92
49-50	0.00	0.00	0.00	0.00	1.16	1.66	3.96	1.95	1.81	0.85	0.40	0.27	12.06
50-51	0.00	0.00	1.91	1.59	3.58	4.19	3.36	1.69	1.04	0.70	0.66	0.00	18.72
51-52	0.00	0.00	0.00	1.42	2.54	4.89	5.25	1.26	3.63	1.51	0.01	0.00	20.51

N.R.—No Record.

RECORD OF MONTHLY PRECIPITATION AT LOCKEFORD, CALIFORNIA

County: San Joaquin
Date established: 1926
Elevation: 106 feet, U. S. G. S. datum

Station number on Plate 3: 5-152
Location: SW ¼, Sec. 30, T. 4 N., R. 8 E., M. D. B. & M.
Record obtained from: J. A. Hammond

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1926-27	0.00	0.00	0.00	1.25	4.05	0.78	2.72	4.33	2.65	0.93	0.35	0.41	17.47
27-28	0.00	0.00	0.02	1.90	1.85	2.09	0.69	1.65	4.01	1.32	0.35	0.00	13.88
28-29	0.00	0.00	T	0.04	3.04	1.91	1.80	1.02	1.48	0.49	0.12	1.09	10.99
29-30	0.00	0.00	0.00	0.01	0.00	1.89	4.34	2.04	2.13	0.99	0.18	0.00	11.58
30-31	0.00	0.27	0.20	0.36	1.48	0.81	2.63	1.60	1.22	0.07	0.61	0.71	9.96
1931-32	0.00	0.00	0.00	1.04	1.60	5.67	1.72	2.57	0.96	0.58	0.32	0.00	14.46
32-33	0.03	0.00	0.00	0.00	0.45	1.94	3.76	0.82	2.04	0.16	1.12	0.13	10.45
33-34	0.00	0.00	0.05	1.34	0.00	5.98	0.61	3.81	0.00	0.14	0.08	0.16	12.17
34-35	0.00	0.00	0.25	0.88	1.54	2.52	3.17	1.48	2.41	4.08	0.03	0.00	16.36
35-36	0.00	T	0.00	1.11	1.00	2.22	5.39	8.42	1.18	1.03	0.66	0.06	21.07
1936-37	0.00	0.00	0.22	0.85	0.00	3.45	4.39	5.39	7.04	1.45	0.08	0.17	23.04
37-38	0.00	0.00	0.00	0.37	2.35	3.16	3.76	6.15	4.94	1.22	T	0.00	21.95
38-39	0.00	0.00	0.11	1.36	0.50	0.79	2.32	1.42	2.58	0.13	1.12	0.00	10.33
39-40	0.00	T	0.84	0.54	0.04	1.14	7.19	5.63	4.12	0.61	0.07	T	20.18
40-41	0.00	0.00	0.00	0.65	0.15	6.48	3.79	5.05	2.53	2.79	0.50	0.00	21.94
1941-42	0.00	0.00	0.00	0.52	1.40	5.61	5.21	2.28	2.31	4.41	1.28	0.00	23.02
42-43	T	0.00	0.10	0.08	3.23	2.19	5.46	2.13	4.54	1.75	0.06	0.10	19.64
43-44	0.00	0.00	0.00	0.28	0.67	1.71	2.54	5.31	0.98	1.73	0.47	0.05	13.74
44-45	0.00	0.00	0.10	2.27	2.89	1.66	1.78	2.99	3.95	0.22	0.32	0.30	16.48
45-46	0.05	T	T	2.02	1.89	4.69	0.80	1.48	2.45	T	1.11	0.00	14.49
1946-47	T	0.00	0.13	0.42	3.70	1.77	0.71	1.33	2.60	0.27	0.11	0.51	11.55
47-48	0.00	0.00	0.00	2.28	1.85	1.18	0.81	1.35	3.53	2.92	2.33	0.04	16.27
48-49	0.00	0.00	T	0.90	0.50	3.52	1.03	2.47	5.49	0.00	0.22	0.00	14.13
49-50	0.00	T	0.00	T	1.10	1.59	4.87	2.67	1.87	0.66	0.25	0.11	13.12
50-51	0.00	0.00	0.85	1.89	5.15	4.23	3.34	2.35	0.81	0.74	0.70	0.00	20.06
51-52	0.00	0.00	0.00	0.95	2.31	6.17	5.94	1.97	4.02	1.63	0.05	0.06	23.10

T—Trace.

RECORD OF MONTHLY PRECIPITATION AT VALLEY SPRINGS, CALIFORNIA

County: Calaveras
Date established: 1920
Elevation: 673 feet, U. S. G. S. datum

Station number on Plate 3: 5-156
Location: NW ¼, Sec. 24, T. 4 N., R. 10 E., M. D. B. & M.
Record obtained from: J. J. Lillie; East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1929-30	0.00	0.23	0.00	0.00	0.00	2.99	4.99	3.75	2.32	1.12	0.76	0.00	16.16
30-31	0.00	0.35	0.08	0.31	1.92	0.83	2.99	2.59	1.08	0.78	1.00	0.40	12.33
31-32	0.00	0.00	0.00	0.66	2.90	6.02	2.22	3.70	1.09	1.34	1.21	0.02	19.16
32-33	0.02	0.00	0.00	0.00	0.57	2.55	5.00	1.12	2.91	0.30	1.17	0.07	13.71
33-34	0.00	0.00	0.08	1.45	0.03	7.35	1.88	5.33	0.02	0.30	1.07	0.24	17.75
1934-35	0.00	0.00	0.21	1.96	2.85	2.40	4.13	1.13	3.39	6.34	0.05	0.00	22.46
35-36	0.00	0.00	0.05	1.41	1.15	2.11	6.48	12.79	1.84	0.12	0.58	0.99	27.52
36-37	0.00	0.00	0.16	1.22	0.00	4.85	4.04	6.92	7.23	1.69	0.08	0.42	26.61
37-38	0.00	0.00	0.00	0.58	2.48	3.91	5.91	7.51	5.93	2.10	0.05	0.00	28.47
38-39	0.00	0.00	0.08	2.12	0.73	1.71	2.54	1.83	2.98	0.28	1.74	T	14.01
1939-40	0.00	0.00	0.97	0.83	0.41	0.96	8.25	6.39	4.86	0.66	0.00	0.00	23.42
40-41	0.00	0.00	0.00	1.08	0.52	6.32	2.97	4.19	2.90	2.77	0.23	0.00	20.98
41-42	0.00	0.00	0.22	0.37	1.48	5.66	6.38	2.58	1.40	4.39	1.97	0.00	24.45
42-43						No	Record						
43-44						No	Record						
1944-45	N.R.	N.R.	N.R.	1.55	4.44	2.07	0.49	4.46	4.09	0.81	0.44	0.00	N.R.
45-46	0.00	0.00	0.00	2.08	3.72	5.85	1.07	1.71	2.03	0.00	1.42	0.00	17.88
46-47	0.00	0.00	0.21	1.01	4.45	1.74	0.99	1.80	3.27	0.52	0.19	0.39	14.57
47-48	0.00	0.00	0.00	3.65	1.59	1.54	0.67	2.35	4.72	5.42	3.13	0.00	23.07
48-49	0.00	0.00	0.00	0.79	0.40	3.96	1.71	2.85		No	Record		
1949-50						No	Record						
50-51	N.R.	N.R.	N.R.	3.26	7.05	5.65			No	Record			
51-52	N.R.	N.R.	N.R.	1.47	4.13	6.55	7.41	2.80	5.26	2.07	0.34	0.00	30.03

N.R.—No Record.

RECORD OF MONTHLY PRECIPITATION AT FARMINGTON, CALIFORNIA

County: San Joaquin
Date established: 1919
Elevation: 110 feet, U. S. G. S. datum

Station number on Plate 3: 5-177
Location: NW ¼, Sec. 16, T. 1 N., R. 9 E., M. D. B. & M.
Record obtained from: J. D. and L. A. Toda; O. S. Beck

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1919-20						2.52	0.28	0.80	5.86	1.37	0.00	0.19	
20-21	0.00	0.18	0.00	0.89	2.25	4.87	4.97	1.25	0.72	0.01	1.89	0.00	18.05
21-22	0.00	0.00	0.02	0.22	0.80	3.80	2.91	4.69	2.25	0.50	0.00	0.00	15.86
22-23	0.00	0.00	0.00	0.46	3.19	5.34	2.63	1.64	0.00	3.08	0.18	0.00	16.52
23-24	0.00	0.00	1.54	0.57	0.92	1.18	1.82	0.55	1.27	1.33	0.00	0.00	8.18
1924-25	0.00	0.00	0.00	1.01	1.55	2.93	1.15	3.85	2.15	2.86	2.87	0.00	18.19
25-26	0.07	0.07	0.20	0.44	0.90	1.51	1.05	3.59	0.67	3.29	0.03	0.00	12.19
26-27	0.00	T	0.00	0.52	4.27	1.23	2.33	3.37	1.11	1.28	0.03	0.40	14.54
27-28	0.00	0.00	0.00	2.27	1.50	1.86	0.88	2.58	3.25	0.79	0.14	0.00	12.27
28-29	0.00	0.00	0.00	0.00	2.80	1.84	1.81	0.96	0.79	0.79	0.10	1.43	10.52
1929-30	0.00	0.00	0.00	0.03	0.00	1.58	3.80	1.91	1.76	0.90	0.27	0.00	10.25
30-31	0.00	0.21	0.00	0.89	1.10	0.00	3.41	1.49	1.10	0.05	0.85	0.47	9.57
31-32	0.00	0.00	0.00	0.22	2.50	4.91	1.55	2.69	0.51	0.34	0.49	0.00	13.21
32-33	0.00	0.00	0.00	0.00	0.22	1.80	4.07	1.06	1.38	0.00	1.22	0.00	9.75
33-34	0.00	0.00	0.13	0.96	0.00	3.82	0.78	3.47	0.00	0.00	0.30	0.09	9.55
1934-35	0.00	0.00	0.13	0.31	2.25	2.06	3.29	0.49	3.24	4.97	0.00	0.00	16.74
35-36	0.00	0.00	0.00	1.19	0.92	1.96	3.54	7.69	1.63	1.43	0.76	0.55	19.67
36-37	0.00	0.00	0.31	0.60	0.00	3.21	3.31	4.28	6.31	1.84	0.00	0.00	19.86
37-38	0.00	0.00	0.00	0.23	1.47	3.51	1.71	5.07	3.64	1.81	0.16	0.00	17.60
38-39	T	0.00	0.06	1.06	0.56	1.30	2.35	1.60	2.41	0.14	0.44	T	9.92
1939-40	0.00	0.00	0.65	0.34	0.11	0.51	5.19	6.03	3.47	0.62	N.R.	N.R.	16.92
40-41	0.00	0.00	T	0.58	0.22	4.44	2.98	3.18	3.09	2.55	T	T	17.04
41-42	0.00	0.00	0.00	0.42	0.95	4.43	4.30	1.44	1.13	3.73	1.56	0.00	17.96
42-43	0.00	0.00	0.00	0.11	2.42	1.56	3.25	2.17	3.61	1.44	0.00	0.00	14.56
43-44	0.00	0.00	0.00	0.37	0.58	1.14	2.93	4.34	0.87	1.67	0.29	0.05	12.24
1944-45	0.00	0.00	0.15	0.91	3.41	1.61	0.28	3.19	3.26	0.32	0.17	0.00	13.30
45-46	0.00	0.00	0.00	1.84	1.97	3.15	0.80	1.19	2.20	0.39	1.00	0.00	12.54
46-47	0.09	0.00	0.00	0.72	2.45	1.74	0.43	1.65	2.06	0.08	0.12	0.29	9.69
47-48	0.00	0.00	0.00	1.67	1.24	0.99	0.34	1.15	4.03	3.76	2.31	T	15.49
48-49	0.00	0.00	0.00	0.98	1.07	2.65	0.95	1.82	3.45	0.00	0.18	0.00	11.10
1949-50	0.00	0.05	0.00	0.00	2.37	1.48	4.86	1.90	2.06	1.41	0.17	0.00	14.30
50-51	0.00	0.00	0.91	7.65	4.99	4.17	2.75	1.51	0.70	0.87	N.R.	0.00	----
51-52	0.00	0.00	0.02	0.97	2.01	6.07	3.73	1.44	2.85	2.02	0.05	0.04	19.20

T—Trace. N.R.—No Record.

RECORD OF MONTHLY PRECIPITATION AT CLAY, CALIFORNIA

County: Sacramento
Date established: 1933
Elevation: 100 feet, U. S. G. S. datum

Station number on Plate 3: 5-0151
Location: SW ¼, Sec. 25, T. 6 N., R. 7 E., M. D. B. & M.
Record obtained from: C. A. Bolton; East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1936-37	0.00	0.00	0.00	0.80	T	3.09	3.60	4.66	5.82	1.46	0.00	0.32	19.75
37-38	0.00	0.00	0.00	0.80	2.20	*3.70	2.55	7.34	4.28	0.98	*0.25	0.00	22.10
38-39	0.00	0.00	0.20	2.80	0.49	1.15	1.81	1.36	2.58	0.23	1.28	0.00	11.90
39-40	0.00	0.00	0.73	0.60	0.07	1.26	6.11	6.01	4.15	0.79	0.00	0.00	19.62
40-41	0.00	0.00	0.00	1.00	0.32	6.94	4.36	5.09	2.82	4.60	0.67	0.20	26.00
1941-42	0.00	0.00	N.R.	*0.58	1.13	5.85	5.44	2.97	2.18	4.83	1.63	0.00	24.61
42-43	0.00	0.00	0.21	0.08	3.19	2.43	5.83	1.96	5.62	1.70	0.10	0.00	21.12
43-44	0.00	0.00	0.00	0.24	0.87	1.74	2.88	6.49	1.41	1.94	0.54	0.13	16.24
44-45	0.00	0.00	0.00	1.34	3.40	2.18	0.65	3.22	3.29	0.32	0.38	0.30	15.08
45-46	0.00	0.00	0.00	2.45	1.97	6.94	0.88	1.54	2.45	0.00	0.90	0.00	17.12
1946-47	0.00	0.00	0.19	0.65	4.10	1.80	0.65	2.17	2.84	0.38	0.12	0.37	13.27
47-48	0.00	0.00	T	2.87	1.45	0.97	0.91	1.87	3.21	3.34	2.35	0.00	16.97
48-49	0.00	0.00	0.00	0.89	0.98	4.14	1.54	2.07	9.38	0.00	0.16	0.00	19.16
49-50	0.00	0.05	0.05	0.07	1.06	1.59	5.00	3.04	1.95	0.80	0.00	0.15	13.76
50-51	0.00	0.00	1.00	2.23	5.37	4.32	3.89	2.25	0.82	0.92	1.80	0.00	22.60
51-52	0.00	0.00	0.00	1.00	2.81	5.64	7.41	1.64	3.95	1.67	0.10	0.00	24.22

* Estimated. T—Trace. N.R.—No Record.

RECORD OF MONTHLY PRECIPITATION AT CLEMENTS, CALIFORNIA

County: San Joaquin
Date established: 1933
Elevation: 120 feet, U. S. G. S. datum

Station number on Plate 3: 5-0159
Location: NE ¼, Sec. 16, T. 4 N., R. 8 E., M. D. B. & M.
Record obtained from: East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1933-34	0.00	0.00	0.00	1.43	0.00	5.97	1.80	3.38	0.00	0.08	0.23	0.25	13.14
34-35	0.00	0.00	0.30	1.01	2.11	2.48	2.67	2.75	3.85	4.40	T	0.00	19.57
35-36	0.00	0.00	0.00	1.03	1.00	2.77	6.08	8.32	1.31	1.19	0.55	0.33	22.58
36-37	0.00	0.00	0.00	0.79	0.00	3.89	4.91	5.80	7.73	1.49	0.06	0.12	24.79
37-38	0.00	0.00	0.00	0.40	2.14	3.40	3.02	6.77	5.58	1.39	0.14	0.00	22.84
1938-39	0.00	0.00	0.11	1.34	0.36	1.04	2.30	1.70	2.84	0.18	1.22	0.00	11.09
39-40	0.00	0.00	0.51	0.71	0.06	1.14	6.92	6.65	4.20	0.55	0.09	0.00	20.83
40-41	0.00	0.00	0.00	0.57	0.23	6.25	3.89	3.84	2.85	4.00	0.63	0.08	22.36
41-42	0.00	0.00	0.01	0.40	1.41	5.64	5.30	2.63	1.69	4.19	1.70	0.00	22.97
42-43	0.00	0.00	0.12	0.07	3.36	2.07	5.38	2.29	5.14	1.77	0.00	0.00	20.20
1943-44	0.00	0.00	0.00	0.17	0.74	1.79	2.64	5.82	1.23	2.01	0.41	0.17	14.98
44-45	0.00	0.00	0.14	1.42	4.20	2.36	0.59	4.91	3.79	0.25	0.32	0.34	18.32
45-46	0.03	0.00	0.00	2.47	2.27	4.93	0.70	1.65	2.59	0.16	1.09	0.00	15.89
46-47	0.03	0.00	0.13	0.65	4.75	1.51	0.72	1.49	2.71	0.45	0.11	0.42	12.97
47-48	0.00	0.00	0.00	2.13	N.R.	1.30	0.94	1.49	3.62	2.97	2.13	0.03	----
1948-49	0.00	0.00	0.00	0.78	0.55	3.79	1.51	2.77	5.31	0.00	0.27	0.00	14.98
49-50	0.00	0.02	0.00	0.00	1.24	1.59	4.88	3.04	2.01	0.87	0.27	0.11	14.03
50-51	0.04	0.00	0.64	2.67	5.10	4.41	4.07	2.13	1.15	0.68	1.00	0.00	21.89
51-52	0.00	0.00	0.00	1.02	2.11	6.55	6.74	1.97	4.44	1.39	0.08	0.07	24.37

T—Trace.

RECORD OF MONTHLY PRECIPITATION AT LIND'S AIRPORT, CALIFORNIA

County: San Joaquin
Date established: 1938
Elevation: 60 feet, U. S. G. S. datum

Station number on Plate 3: 5-0161
Location: SW ¼, Sec. 12, T. 4 N., R. 6 E., M. D. B. & M.
Record obtained from: East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1936-37		No	Record			2.29	3.22	5.16	5.31		No	Record	--------
37-38	No	Record		0.22	1.86	3.54	2.20	7.13	4.25	0.82	0.15	N.R.	--------
38-39	0.00	0.00	0.09	0.73	1.16	0.61	2.06	1.34	1.80	0.10	0.55	0.00	8.44
39-40	0.00	0.00	0.52					No	Record				

N.R.—No Record.

RECORD OF MONTHLY PRECIPITATION AT VICTOR, CALIFORNIA

County: San Joaquin
Date established: 1937
Elevation: 80 feet, U. S. G. S. datum

Station number on Plate 3: 5-0168
Location: NE ¼, Sec. 27, T. 4 N., R. 7 E., M. D. B. & M.
Record obtained from: East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1937-38	No	Record		*0.26	*2.19	4.83	2.58	7.51	5.21	0.87	0.29	0.00	----
38-39	0.00	0.00	0.00	1.25	0.58	0.76	2.31	2.15	2.62	0.10	0.66	0.00	10.43
39-40	0.00	0.00	0.41	0.82	0.00	1.02	7.71	6.53	3.89	0.65	0.00	0.00	21.03
40-41	0.00	0.00	0.00	0.39				No	Record				

* Estimated.

RECORD OF MONTHLY PRECIPITATION AT CHILD'S RANCH, CALIFORNIA

County: San Joaquin
Date established: 1937
Elevation: 150 feet, U. S. G. S. datum

Station number on Plate 3: SJ-1
Location: SE ¼, Sec. 4, T. 4 N., R. 9 E., M. D. B. & M.
Record obtained from: East Bay Municipal District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1937-38	No	Record		0.47	2.46	3.32	2.90	7.76	5.06	1.04	0.54	0.00	----
38-39	0.00	0.00	0.10	1.30	0.54	1.16	2.31	1.82	3.23	0.25	1.26	0.02	11.99
39-40	0.00	0.00	0.74	0.83	0.11	1.05	8.24	6.59	4.41	0.82	0.10	0.00	22.89
40-41	0.00	0.00	0.00	0.72	0.53	6.16	3.82	4.52	1.17	5.24	0.40	0.00	22.56

RECORD OF MONTHLY PRECIPITATION AT MARSHALL RANCH, CALIFORNIA

County: San Joaquin
Date established: 1925
Elevation: 60 feet, U. S. G. S. datum

Station number on Plate 3: SJ-2
Location: SW ¼, Sec. 16, T. 3 N., R. 7 E., M. D. B. & M.
Record obtained from: East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1937-38	No	Record		0.31	2.48	3.53	3.32	6.70	4.73	0.83	0.17	0.00	----
38-39	0.00	0.00	0.14	1.30	0.71	0.81	2.07	1.54	2.25	0.10	0.87	0.00	9.79
39-40	0.00	0.00	0.44	0.90	0.06	0.90	6.39	5.83	3.24	0.61	0.12	T	18.49
40-41	0.00	0.00	0.02	0.63	0.23	6.02	3.85	3.43	1.84	3.17	0.90	0.00	20.09
41-42	0.00	0.00	0.00	0.60	1.51	5.03	4.81	1.91	1.97	3.77	1.42	0.00	21.02
1942-43	0.00	0.00	0.19	0.20	3.49	2.28	5.37	2.55	3.71	1.56	0.03	0.00	19.38
43-44	0.00	0.00	0.00	0.17	0.82	1.54	2.36	5.46	0.88	1.76	0.50	0.16	13.65
44-45	0.00	0.00	0.05	1.29	3.18	2.05	0.53	3.32	3.77	0.20	0.39	0.31	15.09
45-46	0.00	0.00	0.00	2.33	1.47	4.48	0.76	0.96	2.30	0.16	1.05	0.00	13.51
46-47	T	T	0.04	0.90	3.56	1.57	0.53	1.51	2.68	0.17	0.14	0.47	11.57
1947-48	0.00	0.00	0.02	2.33	1.35	1.10	0.63	1.05	3.35	3.01	2.25	0.00	15.09
48-49	0.00	0.00	0.00	1.27	0.44	3.26	1.26	1.86	5.28	0.00	0.15	0.00	13.52
49-50	0.00	0.00	0.00	0.01	0.90	1.41	4.87	2.13	1.82	0.58	0.15	0.08	12.04
50-51	0.00	0.00	0.68	1.83	4.85	4.46	3.10	1.74	1.18	0.91	1.11	0.00	19.86
51-52	0.00	0.00	0.00	1.00	2.17	5.20	5.49	1.87	4.68	1.37	0.08	0.05	21.91

T—Trace.

RECORD OF MONTHLY PRECIPITATION AT MOFFATT RANCH, CALIFORNIA

County: San Joaquin
Date established: 1937
Elevation: 75 feet, U. S. G. S. datum

Station number on Plate 3: SJ-3
Location: NE ¼, Sec. 20, T. 4 N., R. 8 E., M. D. B. & M.
Record obtained from: East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1937-38	No	Record		0.36	2.37	2.98	1.81	7.31	5.39	1.48	0.23	0.00	----
38-39	0.00	0.00	0.00	1.54	0.31	1.03	2.06	1.38	2.60	0.16	1.08	0.00	10.16
39-40	0.00	0.00	*0.67					No	Record				

* Estimated.

RECORD OF MONTHLY PRECIPITATION AT WOODBRIDGE, CALIFORNIA

County: San Joaquin
Date established: 1937
Elevation: 45 feet, U. S. G. S. datum

Station number on Plate 3: SJ-4
Location: NW ¼, Sec. 35, T. 4 N., R. 6 E., M. D. B. & M.
Record obtained from: East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1937-38	No	Record		0.34	1.91	3.83	2.66	8.00	5.02	0.91	0.21	0.00	----
38-39	0.00	0.00	0.24	1.23	0.83	0.81	2.34	1.98	1.91	0.12	0.69	0.00	10.15
39-40	0.00	0.00	0.32	0.55	0.18	0.88	7.34	6.36	3.51	0.85	0.05	0.02	20.06
40-41	0.00	0.00	0.01	0.65	0.13	7.56	3.91	3.92	2.71	3.67	0.47	0.00	23.03
41-42	0.00	0.00	0.00	0.74	1.54	4.69	4.68	2.12	2.03	3.73	1.52	0.00	21.05
1942-43	0.00	0.00	0.10	0.29	3.81	2.49	4.89	2.13	5.56	1.50	0.07	0.01	20.85
43-44	0.00	0.00	0.00	0.22	0.11	1.96	2.37	5.33	0.90	1.72	0.68	0.00	14.29
44-45	0.00	0.00	T					No	Record				

T—Trace.

RECORD OF MONTHLY PRECIPITATION AT YOUNGSTOWN, CALIFORNIA

County: San Joaquin
Date established: 1938
Elevation: 65 feet, U. S. G. S. datum

Station number on Plate 3: SJ-5
Location: SW ¼, Sec. 20, T. 4 N., R. 7 E., M. D. B. & M.
Record obtained from: East Bay Municipal Utility District

(In inches)

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1938-39	No	Record		1.31	0.42	0.93	2.02	1.39	2.00	0.08	0.57	0.00	----
39-40	0.00	0.00	0.35	0.62	0.05	0.76	6.82	6.02	3.52	0.77	0.15	0.00	19.06
40-41	0.00	0.00	0.00	0.60	0.22	6.96	3.46	3.60	2.05	3.57	0.64	0.00	21.10
41-42	0.00	0.00	0.00	1.11	1.46	4.83	4.67	1.87	1.99	4.04	1.52	0.00	21.49
42-43	0.00	0.00	*0.12	0.05	3.70	2.36	4.97	1.63	5.30	1.64	0.32	0.00	20.09
1943-44	0.00	0.00	0.00	0.12	0.76	1.63	2.40	5.95	1.07	1.42	1.42	0.11	13.88
44-45	0.00	0.00	0.00	1.64	3.13	1.93	0.57	3.56	3.50	0.25	0.20	0.26	15.04
45-46	0.03	0.00	0.00	2.24	1.77	5.31	0.81	0.96	2.07	0.08	0.77	0.00	14.08
46-47	0.00	0.00	0.08	0.68	2.68	1.75	0.70	0.97	2.51	0.28	0.08	0.37	10.10
47-48	0.00	0.00	0.02	2.66	1.59	0.83	0.79	1.25	3.35	2.57	2.26	0.00	15.32
1948-49	0.00	0.00	0.00	1.20	0.66	3.93	1.29	2.16	6.80	0.00	0.14	0.00	16.18
49-50	0.00	0.02	0.00	0.07	1.05	1.38	4.42	2.00	1.82	0.58	0.22	0.20	11.76
50-51	0.00	0.00	0.90	2.11	5.07	4.17	3.27	1.57	1.13	0.65	0.84	0.00	19.71
51-52	0.00	0.00	0.00	0.99	2.26	5.95	5.63	1.77	3.84	1.74	0.05	0.18	22.41

* Estimated.

APPENDIX D

RECORDS OF DAILY RUNOFF AND INTERMITTENT SURFACE MEASUREMENTS IN SAN JOAQUIN AREA NOT PREVIOUSLY PUBLISHED

TABLE OF CONTENTS

TABLE 1

DRY CREEK AT FORNI RANCH, 1949-50

Location: SE ¼, Sec. 11, T. 5 N., R. 8 E., M. D. B. & M. Station number on Plate 3: 5-827

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1												
2												
3												
4												
5				NO FLOW								
6												
7												
8												
9												
10												
11				0.2								
12				15								
13				7.9								
14				43								
15				50								
16	NO FLOW	NO FLOW	NO FLOW	136								
17				985								
18				440								
19				238								
20				170								
21				184								
22				226								
23				269								
24				288								
25				193								
26				*								
27												
28												
29												
30												
31												
Average				216.3								
Runoff in acre-feet				6,430								

* Station discontinued.

TABLE 1—Continued

DRY CREEK NEAR IONE, 1949-50

Location: SE ¼, Sec. 33, T. 6 N., R. 9 E., M. D. B. & M. Station number on Plate 3: SJ-4

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1					106	53	84	18				
2					89	39	75	24				
3					82	36	64	51				
4					*2,096	34	56	58				
5					*2,204	32	51	51				
6					*1,796	34	45	43				
7					*785	31	62	39				
8					*428	27	366	31				
9					*310	27	583	24				
10					*258	25	366	22				
11					218	34	258	*16				
12					158	53	196	*15				
13					132	31	164	*13				
14					127	34	148	*11				
15					116	31	121	*10				
16					100	27	105	*9	NO FLOW	NO FLOW	NO FLOW	NO FLOW
17					89	34	89	*8				
18					82	49	73	*7				
19					73	64	64	*6				
20					69	148	56	*5				
21					62	89	49					
22					58	75	47					
23					56	94	45					
24					53	636	40					
25					49	668	36					
26				118	47	348	31	NO FLOW				
27				110	47	237	31					
28				810	60	182	25					
29				340		141	22					
30				181		113	19					
31				128		97						
Average				337.4	348.2	113.6	112.4	23.5				
Runoff in acre-feet				3,340	19,330	6,990	6,680	910				

* Estimated. Recorder installed 1/25/50.

TABLE 1—Continued

JACKSON CREEK AT HIGHWAY 88, 1949-50

Location: NW ¼, Sec. 9, T. 5 N., R. 9 E., M. D. B. & M. Station number on Plate 3: SJ-5

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1					50	11	31	*2				
2					29	9.5	22	*3				
3					15	7.2	48	*10				
4					888	6.4	22	*13				
5					567	6.0	13	*10				
6					609	5.2	13	*7				
7					234	4.4	19	*6				
8					142	3.2	133	*4				
9					107	3.2	169	*3				
10					92	3.0	118	*2				
11					91	5.2	81	*1				
12					71	11	64	*1				
13					64	4.0	56	*1				
14					56	5.6	50	*0				
15					52	4.4	43					
16					45	4.4	35		NO FLOW	NO FLOW	NO FLOW	NO FLOW
17					38	8.0	24					
18					33	18	19					
19					33	25	13					
20					28	64	12					
21					26	35	2.3					
22					24	48	6.8					
23					15	49	5.6	NO FLOW				
24					13	339	5.2					
25					10	208	4.4					
26				43	13	119	*4					
27				38	40	92	*4					
28				333	13	73	*3					
29				117		59	*2					
30				69		51	*2					
31				59		43						
Average				109.8	121.3	42.7	34.1	9.6				
Runoff in acre-feet				1,307	6,738	2,625	2,030	125				

* Estimated. Recorder installed 1/25/50. Recorder removed 4/26/50.

TABLE 2

DRY CREEK NEAR GALT, 1933-34

Location: SW ¼, Sec. 34, T. 5 N., R. 6 E., M. D. B. & M. Station number on Plate 3: 5-829

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	985	18.7	330	21.5					
2			0	2,140	18.4	238	23.1					
3			0	680	18.0	184	21.4					
4			0	300	17.2	151	14.7					
5			0	180	16.1	128	13.2					
6			0	145	15.4	113	8.0					
7			0	125	16.3	95	11.4					
8			0	101	40	81	7.4					
9			0	82	187	72	4.6					
10			0	64	131	64	3.7					
11			0	52	92	57	4.4					
12			0	41	66	54	6.7					
13			0	35	54	50	5.5					
14			0	31	48	47	3.4					
15			53	29	44	42	1.9					
16	NO FLOW	NO FLOW	103	30	182	39	0.9	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW
17			62	28	310	37	0.1					
18			13	26	174	34	0					
19			1.4	23	134	31	0					
20			0.2	26	441	30	0					
21			0	41	350	33	0					
22			0	32	234	33	0					
23			0	25	210	30	0					
24			0	29	499	29	0					
25			0	46	385	26	0					
26			0	34	610	32	0					
27			0	23	1,150	27	0					
28			0	21	498	20	0					
29			0.8	19		19.8	0					
30			313	16		18.4	0					
31			960	15.6		19.3						
Average			48.6	175.0	213	69.8	5.1					
Runoff in acre-feet			2,990	10,800	11,800	4,290	301					

TABLE 2—Continued

DRY CREEK NEAR GALT, 1934-35

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1				0	52	48	86	325	2.5			
2				0	46	54	78	184	5.8			
3				0	38	58	94	149	22			
4				0	38	46	1,030	132	11.2			
5				46	44	52	1,680	115	7.5			
6				141	49	66	1,120	104	5.0			
7				110	63	153	760	94	4.4			
8				116	102	1,200	3,460	89	2.1			
9				362	111	898	4,940	82	1.3			
10				576	116	548	1,920	82	0.9			
11				373	127	396	1,120	78	0.6			
12				214	108	310	750	66	0.2			
13				142	96	265	558	62	0			
14				128	102	226	450	58	0			
15	NO FLOW	NO FLOW	NO FLOW	276	114	192	459	51	0	NO FLOW	NO FLOW	NO FLOW
16				298	96	167	814	50	0			
17				451	82	141	670	49	0			
18				379	77	125	486	51	0			
19				484	72	114	380	43	0			
20				433	62	100	325	37	0			
21				242	53	102	970	38	0			
22				168	49	171	225	31	0			
23				134	46	173	205	28	0			
24				123	43	265	180	29	0			
25				116	39	270	165	25	0			
26				109	36	200	144	26	0			
27				92	36	165	131	20	0			
28				74	38	137	118	12.4	0			
29				67		119	126	6.2	0			
30				58		102	278	3.9	0			
31				58		94		2.5				
Average				186	69	224	767	68.5	2.1			
Runoff in acre-feet				11,400	3,840	13,800	45,700	4,210	126			

TABLE 2—Continued

DRY CREEK NEAR GALT, 1935-36

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	8.4	72	549	436	60	13.5			
2			0	7.0	1,180	476	250	57	13.9			
3			0	25	980	430	203	55	12.1			
4			0	46	440	380	604	52	14.6			
5			0	40	286	330	1,110	52	20			
6			0	33	206	300	594	50	24			
7			0	22	169	291	412	43	30			
8			0	13.4	152	250	320	39	84			
9			0	39	139	220	246	38	70			
10			0	229	129	206	216	36	47			
11			0	788	272	190	166	31	36			
12			0	1,580	3,020	173	149	26	23			
13			0	510	5,060	164	136	23	19			
14			0	940	5,280	156	129	22	11.8			
15	NO FLOW	NO FLOW	0	1,610	3,020	151	127	23	12.1	NO FLOW	NO FLOW	NO FLOW
16			0	1,330	2,230	141	115	25	10.6			
17			0	990	5,420	141	108	24	12.8			
18			0	460	2,040	135	103	23	10.4			
19			0	295	1,270	134	100	21	8.0			
20			0	203	1,270	127	98	19	5.0			
21			0	162	1,290	123	86	17	2.8			
22			0	140	10,700	116	84	12.6	2.0			
23			0	127	8,050	108	86	10.8	1.0			
24			0.8	115	5,840	107	81	10.4	0.5			
25			1.1	102	2,400	130	73	8.3	0.1			
26			1.6	89	1,640	132	72	6.6	0			
27			1.4	79	1,070	117	70	4.9	0			
28			1.7	73	820	105	71	3.6	0			
29			2.3	67	650	106	67	5.0	0			
30			11.0	59		128	65	15	0			
31			14.8	55		265		16				
Average			1.1	330	2,240	206	213	26.7	16.1			
Runoff in acre-feet			69	20,300	129,000	12,700	12,600	1,640	960			

TABLE 2—Continued

DRY CREEK NEAR GALT, 1936-37

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	45	600	336	582	75	8.3			
2			0	27	556	262	558	66	8.5			
3			0	19	770	226	550	63	6.4			
4			0	15	659	196	438	63	4.6			
5			0	15	5,580	175	386	62	9.2			
6			0	17	6,110	162	380	62	7.6			
7			0	21	5,750	154	529	60	3.7			
8			0	16	1,320	148	386	56	0.5			
9			0	17	750	140	302	55	0			
10			0	14	539	133	254	53	0.1			
11			0	13	454	132	207	50	0.3			
12			0	33	490	231	189	51	0.1			
13			0	52	608	764	159	49	0			
14			0	29	1,780	714	140	48	0			
15			0	28	1,700	454	127	44	2.2			
16	NO FLOW	NO FLOW	0	28	874	331	118	37	2.9	NO FLOW	NO FLOW	NO FLOW
17			0	39	616	262	110	34	2.5			
18			0	37	511	285	100	34	6.6			
19			0	33	442	419	94	37	6.2			
20			0	33	370	701	88	38	5.0			
21			0	28	290	1,770	81	31	3.4			
22			0	25	239	10,000	74	28	1.7			
23			0	22	210	2,870	72	26	0.8			
24			0	22	192	3,170	68	19	0.3			
25			0	22	423	4,570	68	19	0.1			
26			0	20	918	1,540	67	15	0			
27			0	23	568	1,290	70	19	0			
28			26	42	430	1,820	95	24	0			
29			35	327		1,050	108	15	0			
30			27	726		810	86	15	0			
31			35	1,440		676		11				
Average			4.0	104	1,210	1,150	216	40.6	2.9			
Runoff in acre-feet			244	6,400	66,900	71,000	12,900	2,500	170			

TABLE 2—Continued

DRY CREEK NEAR GALT, 1937-38

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	18	1,950	281	360	143	18			
2			0	18	1,880	1,860	326	151	16			
3			0	32	3,780	3,570	308	157	15			
4			0	44	3,880	1,670	304	134	14			
5			0	30	2,510	1,040	476	115	10			
6			0	25	1,220	829	629	103	8			
7			0	22	829	650	413	100	8			
8			0	20	591	567	342	96	6.6			
9			0	20	585	531	304	85	6.1			
10			0	18	1,560	427	293	81	6.9			
11			38	16	7,470	393	255	73	3.6			
12			214	15	9,840	794	234	75	2.9			
13			241	15	2,730	3,780	218	72	2.9			
14			95	14	2,940	3,230	210	69	13			
15			49	32	2,310	1,540	188	64	13			
16	NO FLOW	NO FLOW	35	141	1,300	1,100	196	64	4.3	NO FLOW	NO FLOW	NO FLOW
17			27	110	925	1,840	165	66	2.3			
18			23	140	725	1,310	147	60	1.0			
19			19	122	757	976	147	58	0			
20			17	297	573	930	131	60	0			
21			14	279	447	1,970	136	57	0			
22			15	144	380	1,170	126	54	0			
23			14	90	332	942	123	52	0			
24			28	73	296	1,490	117	49	0			
25			29	60	271	1,750	139	44	0			
26			24	54	243	1,110	180	32	0			
27			21	47	230	877	139	27	0			
28			19	44	224	693	120	24	0			
29			18	129		609	114	23	0			
30			16	273		490	123	20	0			
31			17	221		409		19				
Average			31.4	82.7	1,810	1,250	232	71.8	5.0			
Runoff in acre-feet			1,930	5,080	101,000	77,000	13,800	4,420	301			

TABLE 2—Continued

DRY CREEK NEAR GALT, 1938-39

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1				0	97	26	43					
2				0	49	22	41					
3				0	36	20	42					
4				0	95	22	45					
5				0	112	22	37					
6				89	78	20	31					
7				107	43	21	33					
8				50	234	23	25					
9				27	298	76	23					
10				20	168	526	22					
11				13	107	408	18					
12				12	93	209	15					
13				11	84	136	15					
14				9.8	83	100	17					
15				9.7	67	81	15					
16	NO FLOW	NO FLOW	NO FLOW	6.6	62	67	11	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW
17				9.6	65	59	10					
18				8.9	59	53	9.3					
19				6.6	56	47	7.2					
20				8.6	53	44	5.5					
21				11	53	48	4.6					
22				12	49	44	4.2					
23				11	44	37	4.1					
24				9.7	42	35	4.2					
25				5.6	41	32	5.0					
26				8.9	37	33	2.3					
27				10	32	62	2.4					
28				8.6	30	86	0.7					
29				15		65	0.2					
30				18		57	0					
31				94		48						
Average				19	85	82	16					
Runoff in acre-feet				1,170	4,690	5,020	977					

TABLE 3

DRY CREEK NEAR GALT, 1942-43

Location: NE ¼, Sec. 32, T. 5 N., R. 7 E., M. D. B. & M. Station number on Plate 3: 5-829a

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			29	133	1,050	474	368	124	31			
2			39	115	711	378	340	112	44			
3			25	94	586	323	310	110	40			
4			19	79	463	374	282	102	31			
5			14	72	406	963	347	95	25			
6			12	66	365	6,340	722	89	22			
7			70	58	332	3,130	440	85	20			
8			65	53	499	2,540	381	72	15			
9		NO FLOW	41	52	452	4,770	371	63	13			
10			37	48	383	9,500	331	59	9			
11			34	45	342	6,060	295	56	10			
12			28	54	295	1,870	260	54	9			
13			25	44	259	1,040	234	52	10			
14			23	41	229	983	215	48	13			
15			21	39	204	978	198	48	6			
16			20	38	184	675	191	46	1			
17	NO FLOW		18	36	164	758	181	47	0			
18		333	15	33	153	2,650	167	47	0			
19		460	16	29	144	985	156	44	0	NO FLOW	NO FLOW	NO FLOW
20		169	14	35	135	697	147	41	0			
21		78	15	61	132	612	141	40	0			
22		46	16	6,240	205	767	133	39	0			
23		28	137	6,520	430	623	125	36	0			
24		15	660	2,930	645	523	122	31	0			
25		10	535	1,060	1,020	468	118	23	0			
26		6	295	745	980	433	116	22	0			
27		29	199	1,040	1,020	401	115	20	0			
28		112	157	863	669	371	225	17	0			
29		61	329	729		358	253	16	0			
30		39	214	2,590		560	152	15	0			
31			159	3,720		415		17				
Average		46.2	106	892	445	1,646	248	53.9	10.0			
Runoff in acre-feet		2,750	6,510	54,900	24,700	101,200	14,760	3,310	590			

TABLE 3—Continued

DRY CREEK NEAR GALT, 1943-44

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1				0	49	1,348	32					
2				0	45	507	29					
3				0	300	322	28					
4				0	443	2,041	27					
5				0	194	3,832	30					
6				0	98	836	30					
7				0	74	466	27					
8				0	153	328	25					
9				0	690	268	38					
10				0	339	222	38					
11				0	164	194	33					
12				0	118	176	96					
13				0	90	159	63					
14				0	74	148	55					
15	NO FLOW	NO FLOW	NO FLOW	0	65	130	41	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW
16				0	66	121	33					
17				0	49	120	30					
18				0	40	106	29					
19				0	38	95	28					
20				0	36	87	115					
21				0	41	777	120					
22				0	374	70	87					
23				0	532	64	70					
24				4	280	60	60					
25				39	177	58	50					
26				29	127	53	43					
27				20	96	49	43					
28				18	101	45	45					
29				17	2,448	41	36					
30				17		39	30					
31				37		36						
Average				5.8	252	390	47					
Runoff in acre-feet				359	14,480	24,000	2,800					

TABLE 4

BEAR CREEK NEAR LOCKEFORD, 1933-34

Location: SE ¼, Sec. 31, T. 4 N., R. 8 E., M. D. B. & M. Station number on Plate 3: 5-791

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	412	1.0	19	0.3					
2			0	116	1.0	12	0.1					
3			0	37	0.9	9	0					
4			0	19.5	0.9	7	0					
5			0	10.5	0.9	5.6	0					
6			0	6.0	1.0	4.7	0					
7			0	4.0	1.0	4.2	0					
8			0	3.1	59	3.6	0					
9			0	2.5	14	3.2	0					
10			0	2.2	5.0	2.8	0					
11			0	1.8	3.0	2.5	0					
12			0	1.5	2.0	2.3	0					
13			26	1.4	1.5	2.1	0					
14			41	1.2	1.2	1.9	0					
15	NO FLOW	NO FLOW	97	1.2	119	1.8	0	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW
16			18	1.1	242	1.7	0					
17			2.4	1.1	38	1.7	0					
18			1.1	1.2	18	1.5	0					
19			0.6	1.1	98	1.4	0					
20			0.4	1.6	172	1.2	0					
21			0.3	1.9	35	1.2	0					
22			0.2	1.4	18	1.1	0					
23			0.2	1.3	120	1.0	0					
24			0.2	1.9	90	1.0	0					
25			0.1	2.1	28	0.9	0					
26			0	1.5	388	0.8	0					
27			0	1.2	78	0.6	0					
28			0	1.1	36	0.6	0					
29			346	1.0		0.6	0					
30			505	0.9		0.5	0					
31			98	0.9		0.5						
Average			36.7	20.7	56.2	3.2	0.013					
Runoff in acre-feet			2,250	1,270	3,120	194	0.8					

TABLE 4—Continued

BEAR CREEK NEAR LOCKEFORD, 1934-35

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1				0	0.4	0.4	1.4	5.8				
2				0	0.4	0.4	1.6	3.2				
3				0	0.3	0.4	109	1.6				
4				0	0.3	0.4	78	1.0				
5				73	0.3	0.2	53	0.8				
6				16	0.7	0.2	19	0.6				
7				5.8	0.8	140	117	0.4				
8				83	1.2	89	489	0.4				
9				87	1.8	30	59	0.4				
10				21	5.1	11.2	24	0.4				
11				6.2	3.4	6.0	17	0.4				
12				3.7	2.0	4.4	12	0.4				
13				2.2	2.2	3.6	8.2	0.2				
14				1.9	9.5	2.4	6.8	0.2				
15	NO FLOW	NO FLOW	NO FLOW	3.2	6.0	1.6	10.6	0.1	NO FLOW	NO FLOW	NO FLOW	NO FLOW
16				69	3.0	1.2	48	0.1				
17				20	1.6	1.0	18	0.1				
18				44	1.2	1.3	9.9	0				
19				62	0.8	0.8	7.0	0				
20				14.5	0.8	1.3	5.2	0				
21				8.2	0.6	1.8	3.5	0				
22				5.6	0.5	2.0	2.5	0				
23				3.4	0.5	13	2.0	0				
24				2.2	0.4	16	2.0	0				
25				1.2	0.3	5.0	1.7	0				
26				0.7	0.3	2.8	1.2	0				
27				0.9	0.2	2.0	0.8	0				
28				0.7	0.2	1.5	0.7	0				
29				0.6		1.3	1.5	0				
30				0.6		1.2	11.8	0				
31				0.5		1.2		0				
Average				17.3	1.6	11.1	37.4	0.52				
Runoff in acre-feet				1,060	89	682	2,220	32				

TABLE 4—Continued

BEAR CREEK NEAR LOCKEFORD, 1935-36

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	0.1	88	29	6.8					
2			0	0.2	195	24	3.9					
3			0	0.5	59	19	5.6					
4			0	0.6	22	15	83					
5			0	1.9	14	11.2	23					
6			0	1.2	9.7	9.4	10					
7			0	0.6	7.6	8.2	6.6					
8			0	0.5	5.9	7.0	4.8					
9			0	149	4.4	6.1	3.5					
10			0	183	3.7	5.2	2.8					
11			0	320	320	4.4	2.3					
12			0	54	634	4.1	1.9					
13			0	154	619	3.9	1.6					
14			0	324	585	3.2	1.3					
15	NO FLOW	NO FLOW	0	87	150	2.8	1.2	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW
16			0	175	795	2.5	1.0					
17			0	40	486	2.4	0.9					
18			0	20	193	2.4	0.7					
19			0	13	112	2.2	0.6					
20			0	9.4	128	2.0	0.5					
21			0	6.8	375	1.9	0.3					
22			0	5.2	1,370	1.6	0.3					
23			0	4.1	936	1.5	0.1					
24			0	3.2	213	1.5	0.1					
25			0	2.6	286	2.0	0					
26			0	2.0	93	2.8	0					
27			0	1.6	58	2.0	0					
28			0	1.4	44	1.7	0					
29			0.4	1.2	35	1.7	0					
30			0.5	1.1		2.2	0					
31			0.3	0.9		16						
Average			0.039	50.4	270	6.4	5.43					
Runoff in acre-feet			2	3,100	15,500	395	323					

TABLE 4—Continued

BEAR CREEK NEAR LOCKEFORD, 1936-37

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	8.2	41	12	22	1.9				
2			0	2.5	109	9.1	24	1.4				
3			0	0.9	39	7.5	16	1.1				
4			0	0.3	366	6.2	12	0.8				
5			0	0.1	871	5.4	10	0.8				
6			0	0	1,070	5.2	17	0.7				
7			0	0	252	4.5	12	0.6				
8			0	0	84	3.8	8.4	0.6				
9			0	0	53	3.6	7.1	0.5				
10			0	0	41	3.4	5.9	0.3				
11			0	0	38	4.1	5.1	0.1				
12			0	80	55	133	4.6	0.1				
13			0	22	155	108	4.0	0.1				
14			0	9	385	31	3.5	0.1				
15			0	9	79	20	3.4	0				
16	NO FLOW	NO FLOW	0	8	45	16	2.7	0	NO FLOW	NO FLOW	NO FLOW	NO FLOW
17			0	5.0	31	12	2.4	0				
18			0	2.9	25	20	2.3	0				
19			0	2.8	22	16	2.0	0				
20			0	2.9	18	130	1.8	0				
21			0	2.2	16	895	1.8	0				
22			0	1.2	14	1,150	1.5	0				
23			0	0.7	12	178	1.5	0				
24			0	0.4	11	889	1.5	0				
25			0	0.3	56	329	1.4	0				
26			0	0.3	34	84	1.5	0				
27			0	0.3	20	210	2.6	0				
28			0	59	15	84	6.2	0				
29			0	114		46	4.8	0				
30			0	428		35	2.8	0				
31			41	111		26		0				
Average			1.3	28	141	144	6.4	0.3				
Runoff in acre-feet			81	1,730	7,850	8,880	380	18				

TABLE 4—Continued

BEAR CREEK NEAR LOCKEFORD, 1937-38

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	0	442	119	5.4	1.0				
2			0	0	91	791	4.9	1.0				
3			0	0.1	734	330	4.4	0.8				
4			0	1.7	359	117	4.4	0.7				
5			0	0.6	159	58	12	0.6				
6			0	0.3	74	51	7.3	0.5				
7			0	0.2	50	36	4.9	0.4				
8			0	0.1	38	39	4.0	0.4				
9			0	0.1	129	33	3.8	0.3				
10			0	0	275	22	3.3	0.2				
11			65	0	1,170	45	3.1	0.2				
12			83	0	536	353	2.6	0.1				
13			16	0	107	334	2.4	0				
14			5.0	0	417	89	1.9	0				
15			2.1	13	126	53	1.6	0				
16	NO FLOW	NO FLOW	0.8	10.8	70	80	1.4	0	NO FLOW	NO FLOW	NO FLOW	NO FLOW
17			0.4	5.2	51	125	1.3	0				
18			0.2	17	85	47	1.3	0				
19			0.1	16	72	32	1.3	0				
20			0	44	37	109	1.2	0				
21			0	13	24	66	1.2	0				
22			0	6.3	17	31	1.0	0.1				
23			0	3.5	14.7	21	0.8	0.1				
24			0	1.9	13.3	152	0.7	0.1				
25			0	1.0	11.6	46	1.0	0				
26			0	0.7	8.9	22	1.3	0				
27			0	0.4	7.8	13.0	0.8	0				
28			0	4.6	6.8	10.8	0.7	0				
29			0	40		8.9	0.6	0				
30			0	19		7.1	0.7	0				
31			0	189		5.6		0				
Average			5.6	12.5	183	105	2.7	0.2				
Runoff in acre-feet			342	770	10,200	6,440	161	13				

TABLE 4—Continued

BEAR CREEK NEAR LOCKEFORD, 1938-39

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1					0	0						
2					0	0						
3					0	0						
4					0	0						
5					0	0						
6					0.8	0						
7					0.1	0						
8					17	0						
9					2.8	93						
10					1.3	40						
11					0.5	5.4						
12					0.2	3.0						
13					0.2	2.0						
14					0.2	1.5						
15	NO FLOW	NO FLOW	NO FLOW	NO FLOW	0.1	1.0	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW
16					0.1	0.6						
17					0	0.5						
18					0	0.4						
19					0	0.3						
20					0	0.3						
21					0	0.2						
22					0	0.2						
23					0	0						
24					0	0						
25					0	0						
26					0	0						
27					0	0						
28					0	0						
29						0						
30						0						
31						0						
Average					0.8	4.8						
Runoff in acre-feet					46.2	294						

TABLE 4—Continued

BEAR CREEK NEAR LOCKEFORD, 1939-40

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1				0	12.8	86	80	1.3				
2				0	4.1	49	38	1.4				
3				0	142	29	22	1.2				
4				5.8	48	22	24	1.1				
5				2.8	9.8	16	13.6	1.0				
6				6.9	39	12.0	9.6	0.7				
7				28	33	9.6	7.6	0.8				
8				72	4.8	8.2	6.5	0.8				
9				477	2.6	6.5	6.2	0.4				
10				220	1.8	5.5	5.1	0.2				
11				166	1.5	4.8	4.3	0.6				
12				74	1.2	4.0	3.6	0.7				
13				27	4.1	3.7	2.6	0.1				
14				11.6	364	35	2.4	0.1				
15	NO FLOW	NO FLOW	NO FLOW	6.2	51	5.0	2.0	0.1	NO FLOW	NO FLOW	NO FLOW	NO FLOW
16				4.1	13.5	5.5	1.6	0.1				
17				2.8	178	5.2	1.4	0				
18				2.3	104	4.0	1.3	0				
19				1.6	22	2.5	1.2	0				
20				1.1	8.6	2.3	1.1	0				
21				0.9	5.7	1.9	1.1	0				
22				0.7	5.0	1.8	1.1	0				
23				0.6	30	1.8	0.9	0				
24				0.6	24	1.6	0.8	0				
25				36	289	1.8	0.9	0				
26				211	296	2.9	1.4	0				
27				57	994	84	1.6	0				
28				11.6	391	9.3	1.3	0				
29				4.4	267	17	1.0	0				
30				2.8		383	1.0	0				
31				2.8		700		0				
Average				46.4	115.4	48.0	8.2	0.3				
Runoff in acre-feet				2,850	6,640	2,950	486	21				

TABLE 4—Continued

BEAR CREEK NEAR LOCKEFORD, 1940-41

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	4.7	4.9	205	34	1.5				
2			0	2.5	3.6	213	70	1.2				
3			0	1.5	2.8	122	21	1.1				
4			0	1.8	2.7	142	438	0.9				
5			0	20	2.3	334	627	0.6				
6			0	24	19	72	82	0.4				
7			0	63	24	46	52	0.3				
8			0	26	170	32	38	0.2				
9			0	10.8	208	22	30	0.2				
10			0	5.5	111	18	34	0.2				
11			0	3.0	124	12.8	99	0.1				
12			0	1.8	157	8.0	39	0.1				
13			0	45	47	6.3	23	0.2				
14			0	279	31	44	14.8	0.1				
15			0	69	33	13.7	11.7	0.2				
16	NO FLOW	NO FLOW	0	57	34	9.5	11.3	0.1	NO FLOW	NO FLOW	NO FLOW	NO FLOW
17			0	26	32	7.6	8.6	0				
18			0	14.6	28	6.6	6.6	0				
19			0	14.2	16	5.8	5.5	0				
20			0	37	13.9	4.7	4.1	0				
21			0	210	32	3.7	3.2	0				
22			0	181	26	3.4	2.7	0				
23			0	62	13.7	2.8	2.2	0				
24			0	62	186	2.2	1.9	0				
25			46	43	65	1.9	1.8	0				
26			38	81	36	1.8	1.6	0				
27			321	35	31	1.8	1.5	0				
28			118	19	40	2.5	1.5	0				
29			19	13.2		2.5	1.5	0				
30			10.1	8.8		3.9	1.5	0				
31			8.0	6.1		35		0				
Average			18.0	46.0	53.4	44.7	55.6	0.2				
Runoff in acre-feet			1,110	2,830	2,960	2,750	3,310	14.6				

TABLE 4—Continued

BEAR CREEK NEAR LOCKEFORD, 1941-42

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1			0	21	33	3.7	1.6	5.0	0			
2			0	9.0	94	3.2	1.5	5.5	0			
3			0	5.4	94	2.7	1.5	2.3	0.1			
4			0	3.8	119	2.0	38	1.4	0.1			
5			0	2.5	181	2.5	12.3	1.0	0			
6			0	1.9	187	2.4	12.3	0.7	0			
7			0	1.7	143	2.0	6.0	0.5	0			
8			0	9.4	62	1.8	3.5	0.4	0			
9			0	8.5	35	1.6	2.6	0.3	0			
10			0	4.7	26	1.6	4.5	0.2	0			
11			0	3.0	22	500	10.2	0.7	0			
12			0	2.2	18	61	4.3	1.4	0			
13			0	1.5	13.3	31	2.9	1.1	0			
14			0	1.3	10.2	26	18	0.6	0			
15			0	1.1	8.0	26	10.0	0.5	0			
16	NO FLOW	NO FLOW	0	0.9	7.0	16	6.1	0.5	0	NO FLOW	NO FLOW	NO FLOW
17			0	0.7	6.0	10.8	28	0.3	0			
18			0	0.6	6.0	8.0	13.0	0.2	0			
19			0	0.5	5.8	6.0	6.2	0.2	0			
20			0	0.3	5.2	4.9	4.1	0.2	0			
21			0	0.3	5.5	4.1	2.9	0.2	0			
22			0	0.3	19	3.3	2.2	0.1	0			
23			0	27	8.3	3.0	1.4	0.1	0			
24			0	555	6.7	2.6	1.2	0.1	0			
25			0	491	9.0	2.2	1.0	0.1	0			
26			0	436	6.5	1.9	0.8	0.1	0			
27			11.3	923	5.2	1.4	1.0	0.3	0			
28			73	267	4.5	1.4	1.6	0.2	0			
29			92	85		1.4	2.0	0.1	0			
30			144	51		1.4	1.8	0	0			
31			54	45		1.4		0				
Average			12.1	95.5	40.7	23.8	6.8	0.8	0.007			
Runoff in acre-feet			742	5,870	2,260	1,460	402	48.2	0.4			

TABLE 4—Continued

BEAR CREEK NEAR LOCKEFORD, 1942-43

(Daily meon flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1		0	0	3.7	43	20	6.5	1.0				
2		0	0	2.2	29	12.8	5.5	0.8				
3		0	0	1.0	22	10.6	4.8	0.8				
4		0	0	0.2	17	16	6.0	0.8				
5		0	0	0.2	14	171	49	0.8				
6		0	0	0.1	11	352	31	0.8				
7		0	0	0	9.7	74	11.4	0.7				
8		0	0	0	16	192	6.0	0.6				
9		0	0	0	17	273	4.1	0.6				
10		0	0	0	10	734	2.9	0.3				
11		0	0	0	6.7	130	2.8	0.3				
12		0	0	0	6.0	64	2.6	0.2				
13		0	0	0	4.8	43	2.4	0.1				
14		0	0	0	4.2	84	2.2	0				
15		0	0	0	4.0	54	1.9	0				
16	NO FLOW	0	0	0	3.2	28	1.9	0	NO FLOW	NO FLOW	NO FLOW	NO FLOW
17		0	0	0	2.9	171	1.9	0				
18		0	0	0	2.6	425	1.6	0				
19		2.0	0	0	2.4	66	1.4	0				
20		0.6	0	0.1	2.3	38	1.3	0				
21		0.1	0	523	2.2	28	1.3	0				
22		0	0.1	718	21	52	1.2	0				
23		0	31	548	50	28	1.2	0				
24		0	37	82	67	20	1.2	0				
25		0	46	42	129	16	1.1	0				
26		0	16	46	71	13.2	1.1	0				
27		0	4.5	116	109	12.3	1.1	0				
28		0	18	40	30	11.4	1.4	0				
29		0	20	55		16	1.9	0				
30		0	12	342		8.9	1.2	0				
31			6.5	114		7.6		0				
Average		0.09	6.2	85.0	25.1	102.3	5.3	0.25				
Runoff in acre-feet		5.4	379	5,220	1,390	6,290	317.1	15.5				

TABLE 5

LITTLEJOHNS CREEK AT FARMINGTON, 1942-43

Location: SE ¼, Sec. 22, T. 1 N., R. 9 E., M. D. B. & M. Station number on Plate 3: 5-784

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	*July	*Aug.	*Sept.
1	6	6	22	4	780	330	110	4	4	4	4	4
2	6	6	30	4	700	330	110	4	4	4	4	4
3	6	6	30	4	384	310	100	4	4	4	4	4
4	6	6	30	60	170	180	100	4	4	4	4	4
5	6	6	30	50	110	532	110	4	4	4	4	4
6	6	6	30	50	6	3,315	186	4	4	4	4	4
7	6	6	30	60	6	925	170	4	4	4	4	4
8	6	6	22	60	278	1,165	150	4	4	4	4	4
9	6	6	16	50	184	1,799	130	4	4	4	4	4
10	6	6	30	40	88	2,820	110	4	4	4	4	4
11	6	50	30	30	86	925	70	4	4	4	4	4
12	6	30	22	30	84	310	50	4	4	4	4	4
13	6	16	22	30	72	270	30	4	4	4	4	4
14	6	7	22	30	70	186	16	4	4	4	4	4
15	6	7	22	22	6	270	7	4	4	4	4	4
16	6	2	22	22	6	180	6	4	4	4	4	4
17	6	2	30	30	6	1,165	6	4	4	4	4	4
18	6	7	40	30	6	310	6	4	4	4	4	4
19	6	7	40	30	6	186	6	4	4	4	4	4
20	6	16	40	30	5	180	6	4	4	4	4	4
21	6	16	22	50	72	210	5	4	4	4	4	4
22	6	30	22	2,580	80	210	5	4	4	4	4	4
23	6	30	22	505	72	88	5	4	4	4	4	4
24	6	30	30	300	70	86	4	4	4	4	4	4
25	6	30	30	270	1,270	82	4	4	4	4	4	4
26	6	30	210	189	290	82	4	4	4	4	4	4
27	6	30	70	187	438	80	4	4	4	4	4	4
28	6	22	5	88	370	160	4	4	4	4	4	4
29	6	16	6	88		160	4	4	4	4	4	4
30	6	16	6	1,483		110	4	4	4	4	4	4
31	6		6	720		110		4		4	4	
Average	6	15.1	31.9	230	204.1	550.5	50.7	4	4	4	4	4
Runoff in acre-feet	370	900	1,960	14,130	11,340	33,850	3,020	250	240	250	250	240

* Estimated.

TABLE 5—Continued

LITTLEJOHNS CREEK AT FARMINGTON, 1943-44

(Daily mean flow in second-feet)

Day	*Oct.	*Nov.	*Dec.	*Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1	2	2	2	2	6	586	6	6	5	2	0	0
2	2	2	2	2	6	985	6	6	5	2	0	0
3	2	2	2	2	84	1,951	6	6	5	2	0	0
4	2	2	2	2	361	1,691	6	6	5	2	0	0
5	2	2	2	2	168	2,077	6	6	5	2	0	0
6	2	2	2	2	130	590	6	6	5	2	0	0
7	2	2	2	2	115	179	6	6	5	2	0	0
8	2	2	2	2	118	87	6	6	5	2	0	0
9	2	2	2	2	266	77	6	6	5	2	0	0
10	2	2	2	2	203	72	6	6	4	2	0	0
11	2	2	2	2	163	70	6	6	4	2	0	0
12	2	2	2	2	141	52	6	6	4	2	0	0
13	2	2	2	2	76	11	6	6	4	2	0	0
14	2	2	2	2	70	6	6	6	4	2	0	0
15	2	2	2	2	70	5	6	5	4	2	0	0
16	2	2	2	2	70	4	6	5	4	1	0	0
17	2	2	2	2	70	9	6	5	4	1	0	0
18	2	2	2	2	70	22	6	5	4	1	0	0
19	2	2	2	2	70	19	6	5	4	1	0	0
20	2	2	2	2	70	7	6	5	3	1	0	0
21	2	2	2	2	210	7	6	5	3	1	0	0
22	2	2	2	2	1,086	7	6	5	3	1	0	0
23	2	2	2	2	3,732	7	6	5	3	1	0	0
24	2	2	2	2	985	7	6	5	3	1	0	0
25	2	2	2	2	190	7	6	5	3	1	0	0
26	2	2	2	2	178	7	6	5	3	0	0	0
27	2	2	2	2	170	7	6	5	3	0	0	0
28	2	2	2	2	344	7	6	5	3	0	0	0
29	2	2	2	2	1,449	7	6	5	3	0	0	0
30	2	2	2	2		7	6	5	2	0	0	0
31	2		2	2		7		5		0	0	
Average	2	2	2	2	368	276.7	6	5.5	3.9	1.3		
Runoff in acre-feet	120	120	120	120	21,170	17,010	360	330	230	80	0	0

* Estimated.

TABLE 6

LITTLEJOHNS CREEK AT FARMINGTON, 1945-46

Location: SE ¼, Sec. 22, T. 1 N., R. 9 E., M. D. B. & M. Station number on Plate 3: 5-784

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1						3	22	5	8	13	16	18
2						3	19	5	7	13	16	18
3						3	18	5	6	12	15	18
4						3	11	5	6	12	15	18
5						2	7	6	6	12	15	18
6						2	5	6	5	12	15	18
7						2	4	5	7	11	15	18
8					NO RECORD	2	3	7	9	11	14	18
9						2	2	6	9	11	14	18
10						2	2	7	9	11	14	18
11						1	1	7	9	11	14	18
12						1	1	7	9	10	14	18
13						1	1	7	9	10	14	17
14					4	1	1	7	9	10	14	17
15					4	1	1	7	9	10	14	17
16					4	1	1	6	8	10	14	17
17	NO RECORD	NO RECORD	NO RECORD	NO RECORD	6	1	1	6	8	10	14	16
18					13	2	2	7	8	10	14	16
19					9	2	2	7	8	10	14	16
20					7	1	2	6	9	10	14	14
21					7	1	2	7	18	9	14	14
22					7	1	3	7	18	9	14	14
23					6	1	4	7	17	9	14	12
24					6	1	4	8	17	9	14	12
25					5	2	5	9	16	12	14	12
26					5	2	6	9	16	12	18	11
27					4	2	7	15	15	14	20	11
28					4	4	6	18	15	14	20	10
29						5	6	16	14	15	19	10
30						4	5	13	14	16	19	9
31						18		9		16	18	
Average						2.5	5.1	7.8	10.6	11.4	15.3	15.4
Runoff in acre-feet						153	306	480	631	703	939	915

TABLE 6—Continued

LITTLEJOHNS CREEK AT FARMINGTON, 1946-47

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1	9	5	6	16	1	2	3	7				
2	8	5	5	12	1	2	3	8				
3	8	5	4	10	1	2	3	9				
4	8	5	4	9	1	440	2	9				
5	7	5	3	7	1	241	2	9				
6	7	5	3	6	1	61	2	9				
7	6	5	3	6	1	32	2	9				
8	6	4	3	5	2	22	1	10				
9	6	4	3	4	2	16	1	11				
10	5	4	3	4	2	281	1	11				
11	5	4	4	4	2	500	1	11				
12	5	3	5	3	10	121	1	12				
13	5	3	5	3	84	57	3	13				
14	5	3	4	3	33	34	4	13				
15	5	3	4	3	26	25	4	14				
16	5	4	4	2	19	20	3	13	NO RECORD	NO RECORD	NO RECORD	NO RECORD
17	5	3	4	2	14	16	3	12				
18	5	3	3	2	11	14	3	12				
19	5	3	3	2	8	11	3	14				
20	11	24	2	2	6	9	3	14				
21	10	22	2	2	5	8	3	15				
22	9	14	2	2	4	7	4	15				
23	8	19	2	1	4	6	3	13				
24	7	27	2	1	3	5	4	15				
25	7	17	3	1	3	5	3	15				
26	7	14	17	2	3	4	5	15				
27	6	14	134	1	3	4	5	18				
28	6	11	142	1	3	4	5	18				
29	6	9	56	1		4	5	18				
30	5	8	31	1		4	6	18				
31	5		21	1		3		18				
Average	6.5	8.5	15.7	3.8	9.1	63	3.0	13				
Runoff in acre-feet	400	510	970	240	500	3,890	180	790				

TABLE 6—Continued

LITTLEJOHNS CREEK AT FARMINGTON, 1947-48

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1				6	0.9	0	12	9	19	11	11	12
2				6	0.8	0	11	9	18	10	11	12
3				6	0.8	0	174	8	16	11	11	12
4				6	0.9	0	256	7	11	11	11	11
5				6	1.0	0	717	6	9	11	11	11
6				6	1.0	0	416	5	8	10	11	11
7				6	0.8	0	232	5	8	9	10	11
8				6	0.7	0	125	4	8	10	9	11
9				6	0.8	0	77	4	9	11	7	10
10				6	0.8	0	59	3	8	11	6	11
11				6	0.5	0	102	5	9	11	6	12
12				6	0.3	0	90	5	9	11	6	11
13				6	0.2	0	67	6	9	10	7	11
14				5	0	0	47	6	9	10	9	10
15				5	0	0	34	5	9	9	9	11
16	NO RECORD	NO RECORD	NO RECORD	4	0	0	24	6	9	9	10	11
17				4	0	0	18	6	10	10	10	11
18				4	0	40	14	7	9	10	10	12
19				4	0	55	11	8	10	10	11	12
20				3	0	27	11	10	10	10	11	11
21				3	0	24	10	11	10	10	11	11
22				2	0	20	10	11	10	10	12	12
23				2	0	13	9	9	10	10	12	11
24				2	0	141	8	8	9	10	11	11
25				2	0	740	8	8	9	10	11	11
26				1	0	220	7	8	9	10	12	10
27				1	0	99	8	9	9	10	12	10
28				1	0	56	9	8	10	10	12	10
29				1	0	35	11	9	11	10	12	10
30				1	0	22	11	10	10	11	12	9
31				0.9	0	14		10		11	12	
Average				4	0.3	48.6	86.3	7.3	10.1	10.2	10.2	11.0
Runoff in acre-feet				250	19	2,990	5,130	450	600	630	630	650

TABLE 6—Continued

LITTLEJOHNS CREEK AT FARMINGTON, 1948-49

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1	9	3	0	0	3	4	11	5	9	8	8	8
2	9	3	0	0	2	9	10	6	9	8	7	8
3	9	3	0	0	1	545	9	6	10	9	7	8
4	10	3	0	0	1	1,560	8	7	11	8	7	8
5	10	2	0	0	1	425	7	7	9	8	7	8
6	10	2	0	0	1	274	6	7	9	8	6	8
7	9	2	0	0	29	135	5	6	7	8	6	8
8	8	2	0	0	232	84	4	8	9	8	6	7
9	8	2	0	0	80	64	4	8	9	7	8	7
10	7	2	0	0	36	68	4	8	10	9	9	7
11	6	2	0	0	23	182	3	9	11	9	9	7
12	7	1	0	0	17	888	4	9	10	9	9	7
13	6	1	0	0	26	407	4	8	10	9	8	6
14	6	1	0	0	20	158	5	9	10	9	7	6
15	6	1	0	0	12	97	6	10	10	7	8	6
16	6	1	0	0	10	68	4	10	10	8	8	6
17	6	1	0	0	8	64	4	11	11	7	9	5
18	6	1	0	0	6	47	4	11	10	7	8	5
19	5	1	0	0	6	54	5	12	9	6	9	5
20	5	1	0	0	5	232	5	12	10	8	10	5
21	4	1	0	0	4	115	5	12	10	8	10	5
22	4	0	0	0	3	93	4	12	11	7	9	5
23	4	0	0	0	3	176	4	12	11	7	9	5
24	4	0	0	0	3	120	4	12	10	6	9	5
25	3	0	0	0	3	93	5	12	9	5	9	5
26	3	0	0	10	3	62	5	10	10	7	9	4
27	3	0	0	6	3	40	5	9	10	7	9	3
28	3	0	0	5	3	29	6	9	8	6	9	1
29	3	0	0	4	----	20	5	10	7	6	8	1
30	3	0	0	3	----	15	5	10	8	8	8	1
31	3	----	0	3	----	13	----	10	----	9	8	----
Average	6.0	1.2	0.0	1.0	19.4	198.1	5.3	93	93	7.6	8.2	5.7
Runoff in acre-feet	370	70	0	60	1,080	12,180	320	570	570	470	500	340

TABLE 6—Continued

LITTLEJOHNS CREEK AT FARMINGTON, 1949-50

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1	2		0		111	12	77	6	4	5	5	3
2	1		----		93	11	32	5	4	5	4	3
3	1		----		80	10	15	5	3	5	4	4
4	0	NO FLOW	----		764	9	11	5	4	5	4	3
5	0		----		1,190	9	10	5	4	5	4	3
6	1			NO FLOW	1,500	8	8	5	4	5	4	3
7	1				517	8	7	6	4	3	4	3
8	1	0			254	8	7	5	4	3	4	3
9	3	0			175	7	8	5	5	4	4	2
10	2	2	NO FLOW		178	7	113	5	5	4	4	2
11	1	16		1	243	7	78	5	5	4	4	3
12	1	8		6	140	6	58	6	5	4	4	3
13	1	9		13	98	6	23	6	5	4	4	3
14	1	4		70	82	5	11	6	5	4	4	4
15	0	2		175	70	11	8	6	6	3	4	3
16	----	2	----	371	62	9	6	6	6	4	4	3
17	----	1	----	3,190	54	8	55	6	6	4	4	3
18	----	1	----	1,030	47	6	5	7	6	4	4	3
19		1	0	334	41	6	4	7	6	3	3	3
20		1	1	190	35	5	4	6	5	5	3	3
21		1	1	136	30	4	3	5	5	4	4	3
22		0	1	96	26	12	4	5	6	5	4	4
23	NO FLOW		1	78	22	10	4	5	5	4	4	5
24			1	106	18	10	4	5	4	4	4	4
25			1	106	16	247	5	5	5	4	3	4
26			0	80	15	240	5	5	5	3	3	3
27		NO FLOW	0	67	14	194	6	5	5	4	3	2
28	----		0	2,350	12	148	6	5	5	4	4	1
29	----		0	715	----	120	6	5	5	4	3	0
30	----		0	278	----	108	6	5	5	4	3	0
31	----		0	169	----	100	----	5	----	4	3	----
Average	0.5	1.6	0.2	308.4	210.3	43.6	18.0	5.4	4.9	4.1	3.8	2.9
Runoff in acre-feet	32	95	12	18,960	11,680	2,680	1,070	330	290	250	230	170

TABLE 6—Continued

LITTLEJOHNS CREEK AT FARMINGTON, 1950-51

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1	0	16	62	58	---	139	21	21	3	3	3	3
2	0	13	59	55		245	20	20	3	3	3	3
3	0	13	940	56		204	19	18	3	3	3	3
4	0	13	2,052	130		176	19	16	2	3	3	3
5	0	12	594	120		915	19	17	2	3	3	3
6	0	11	532	107	NO RECORD	853	19	20	2	3	3	3
7	0	11	2,390	97		486	19	16	3	3	3	3
8	0	10	2,825	89		361	18	13	3	3	3	3
9	0	8	2,740	82		253	18	10	3	3	3	3
10	0	8	1,672	103		208	17	8	3	3	3	3
11	0	8	406	928	---	169	16	7	3	3	3	3
12	0	6	290	2,044	560	144	16	5	3	3	3	3
13	0	5	240	580	333	120	18	7	3	3	3	3
14	0	4	826	326	212	102	18	7	3	3	3	3
15	0	4	625	254	171	93	16	7	2	3	3	3
16	0	4	362	412	141	82	16	8	3	3	3	3
17	0	4	265	288	124	74	16	8	3	3	3	3
18	0	525	217	319	106	66	16	7	3	3	3	3
19	0	2,320	182	670	98	59	17	5	3	3	3	3
20	0	2,060	158	471	88	54	18	6	4	3	3	3
21	2	1,100	139	326	83	47	17	5	4	3	3	3
22	2	301	121	253	78	42	19	4	3	3	3	3
23	2	233	104	274	70	39	19	5	4	3	3	3
24	3	178	94	239	64	34	19	5	3	3	3	3
25	4	145	85	201	60	32	18	5	3	3	3	3
26	4	120	80	176	58	29	15	4	3	3	3	3
27	4	99	71	154	76	28	15	3	3	3	3	3
28	4	90	65	138	98	27	15	3	3	3	3	3
29	4	78	62	124	---	24	19	3	3	3	3	3
30	6	72	58	115	---	23	20	3	3	3	3	3
31	10	---	56	105	---	23	---	3	---	3	3	---
Average	1.5	249	593	300	---	166.2	17.7	8.7	3	3	3	3
Runoff in acre-feet	90	14,820	36,440	18,430	---	10,220	1,050	530	180	180	180	180

TABLE 6—Continued

LITTLEJOHNS CREEK AT FARMINGTON, 1951-52

(Daily mean flow in second-feet)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1	3	2	25	370	613	127	120	---	---	---	---	---
2	3	2	168	360	370	110	93	---	---	---	---	---
3	3	2	88	345	365	98	66	---	---	---	---	---
4	3	2	219	350	359	88	57	---	---	---	---	---
5	3	2	302	345	351	87	48	---	---	---	---	---
6	3	2	246	360	339	87	42	---	---	---	---	---
7	3	2	130	335	320	264	40	---	---	---	---	---
8	3	2	102	330	255	340	41	---	---	---	---	---
9	3	2	84	330	139	342	42	---	---	---	---	---
10	3	2	68	320	122	339	64	---	---	---	---	---
11	3	2	56	300	114	336	60	---	---	---	---	---
12	3	2	45	310	146	345	47	---	---	---	---	---
13	3	2	40	370	129	358	42					
14	3	2	32	366	115	346	38					
15	3	2	29	378	103	719	40					
16	3	2	28	400	94	426	35	NO RECORD	NO RECORD	NO RECORD	NO RECORD	NO RECORD
17	3	2	26	713	138	912	32					
18	3	2	25	1,170	143	904	30					
19	3	2	25	1,140	153	567	27					
20	3	2	25	1,140	207	1,088	26	---	---	---	---	---
21	3	2	24	696	525	1,060	23	---	---	---	---	---
22	3	2	24	674	351	1,040	22	---	---	---	---	---
23	3	2	23	625	351	1,020	22	---	---	---	---	---
24	3	2	22	685	348	1,020	22	---	---	---	---	---
25	3	2	22	559	342	1,040	23	---	---	---	---	---
26	3	2	22	903	333	1,000	21	---	*	---	---	---
27	3	2	22	1,077	315	980	25	---	---	---	---	---
28	3	2	260	1,053	290	980	23	---	---	---	---	---
29	3	2	285	1,041	170	959	20	---	---	---	---	---
30	3	2	305	960	---	924	18	---	---	---	---	---
31	3	---	326	665	---	873	---	---	---	---	---	---
Average	3	2	99.9	602.3	262.1	605.8	40.3	---	---	---	---	---
Runoff in acre-feet	180	120	6,140	37,030	15,070	37,250	2,400	---	---	---	---	---

* Station moved downstream to NE ¼, Sec. 20, T. 1 N., R. 9 E., M. D. B. & M.

TABLE 7

CHEROKEE LANE, 1952

Location: NW ¼, Sec. 19, T. 2 N., R. 7 E., M. D. B. & M. Station number on Plate 2: 1

(Daily mean flow in second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14				*11	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW	NO FLOW
15				1.0								
16				*0.5								
17				*0.5								
18				0.9								
19				0.9								
20				0.9								
21				0								
22				0								
23				0.5								
24				4.1								
25				4.9								
26				4.4								
27				4.6								
28				3.0								
29				2.7								
30				0.9								
31												
Average				2.4								
Runoff in acre-feet				8.1								

* Estimated.

TABLE 7—Continued

COTTA No. 1, 1952

Location: SE ¼, Sec. 9, T. 2 N., R. 6 E., M. D. B. & M. Station number on Plate 2: 2

(Daily mean flow in second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1					8.5	4.3	14	11.1	2.0	16	24	
2					9.1	6.4	10	6.0	5.0	26	20	
3					7.8	4.0	21	3.3	9.7	25	5.4	
4					6.1	8.8	36	6.4	16	18	13	
5					12	26	36	11	19	28	21	
6					12	19	27	21	8.8	20	22	
7					14	12	15	27	18	14	26	
8					8.8	22	10	30	15	8.8	9.7	
9					9.7	35	9.6	17	13	8.3	9.4	
10					4.4	24	7.1	17	23	15	23	
11					3.2	32	12	17	11	9.8	26	
12					2.9	18	28	3.6	13	10	26	
13					7.8	8.6	34	8.8	13	7.3	20	
14					8.4	32	23	16	11	6.3	20	
15					7.6	22	20	11	12	4.6	23	
16					5.3	14	30	11	23	16	20	
17					6.1	4.0	22	11	13	6.8	20	
18					11	9.7	27	20	9.4	13	9.7	
19					14	9.8	13	14	3.4	15	2.9	
20					18	10	5.8	13	8.8	18	0	
21					14	11	6.0	9.2	17	20		
22					9.0	27	10	7.0	14	2.5		
23				6.9	7.0	32	5.4	7.4	15	3.4		
24				7.2	18	25	11	6.8	8.8	15		
25				19	20	23	11	7.1	12	27		
26				19	21	21	29	6.0	12	13		
27				24	22	17	18	12	16	12		
28				27	11	12	19	10	9.9	12		
29				13	7.6	7.6	9.9	5.6	9.7	6.4		
30				8.1	17	17	15	13	15	22		
31						10	9.2	5.0		32		
Average				15.5	10.7	18.0	17.6	11.7	12.6	14.5	17.1	
Runoff in acre-feet				240	660	1,070	1,080	720	750	890	680	

TABLE 7—Continued

FIVE-MILE SLOUGH, 1952

Location: SE ¼, Sec. 9, T. 2 N., R. 6 E., M. D. B. & M. Station number on Plate 2: 3

(Daily mean flow in second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1					6.3	0.3	7.7	3.1	6.0	5.7	1.7	
2					4.1	2.8	4.6	3.9	9.7	7.5	8.5	
3					4.3	0	3.6	5.5	6.7	5.4	7.4	
4					3.0	3.7	1.7	2.2	4.5	2.0	9.8	
5					7.7	6.9	0	2.5	3.5	5.2	8.3	
6					9.9	9.4	4.2	2.2	3.5	9.1	5.9	
7					4.2	15	4.4	4.7	2.3	13	1.3	
8					3.8	21	2.6	5.2	3.2	12	2.2	
9					3.1	22	3.0	6.0	4.3	20	5.1	
10					3.3	5.3	2.6	4.5	3.9	20	12	
11					6.0	2.7	3.3	3.0	4.2	16	5.4	
12					6.7	8.2	1.2	4.2	0.5	11	5.0	
13					7.0	1.7	1.2	5.7	0.6	18	5.9	
14					1.8	4.2	4.6	4.4	0.4	14	7.2	
15					1.7	17	0.8	2.5	1.1	5.8	5.9	
16					2.5	21	1.7	2.8	5.0	7.3	4.7	
17					2.4	12	3.3	4.5	6.1	3.5	2.7	
18					0	8.1	8.8	7.8	3.3	1.3	2.7	
19					0	6.1	9.4	0	2.5	4.7	1.1	
20					2.8	0	8.6	1.2	8.7	9.8	0.3	
21					3.2	7.2	7.2	4.5	8.9	5.0		
22					0.7	9.5	9.3	5.5	8.7	2.9		
23				12	0.7	8.9	9.9	3.9	5.9	6.0		
24				14	6.3	4.6	4.3	3.9	2.9	8.5		
25				6.8	9.6	1.5	4.4	0	3.7	6.3		
26				6.6	6.2	6.2	2.6	4.2	6.3	1.1		
27				5.9	3.8	4.4	8.0	4.9	3.5	3.5		
28				6.3	3.7	5.7	6.0	5.9	9.6	5.2		
29				8.2	3.7	10	2.1	6.3	8.1	0.6		
30				6.6	5.2	6.1	1.7	6.4	12	0.5		
31					0.3		2.4	6.2		0.5		
Average				8.3	4.0	7.8	4.4	4.1	5.0	7.5	5.2	
Runoff in acre-feet				130	250	460	270	250	300	460	200	

TABLE 7—Continued

PIXLEY SLOUGH, 1952

Location: SW ¼, Sec. 5, T. 2 N., R. 6 E., M. D. B. & M. Station number on Plate 2: 4

(Daily mean flow in second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1					24	9.9	8.5	6.9	7.8	3.5	18	
2					18	13	2.7	5.1	10	9.7	9.8	
3					18	15	3.3	8.9	15	5.6	9.0	
4					11	11	3.0	11	20	15	9.5	
5					11	5.4	2.0	9.2	16	12	11	
6					4.1	2.4	2.9	9.0	14	7.9	15	
7					9.5	3.7	2.9	4.6	13	3.8	13	
8					12	4.8	9.0	6.5	7.1	10	13	
9					18	4.2	8.1	20	3.9	8.3	9.6	
10					22	2.2	11	14	5.0	11	11	
11					21	10	16	16	4.3	8.4	7.3	
12					20	9.5	12	8.4	5.1	10	7.5	
13					10	10	10	8.0	2.5	7.3	8.3	
14					6.0	13	9.2	14	5.1	8.3	9.6	
15					8.2	21	3.2	12	10	8.0	5.5	
16					5.5	16	3.3	14	4.3	9.6	4.1	
17					6.8	14	4.9	22	14	9.9	2.0	
18					9.3	16	5.3	8.6	8.1	9.1	1.2	
19					9.9	6.5	3.0	3.9	11	7.0	1.5	
20					8.4	3.4	20	3.5	13	7.2	6.3	
21					7.4	1.8	16	8.6	16	7.2		
22					4.1	1.3	4.2	4.6	17	6.3		
23					5.3	9.9	7.1	6.3	10	8.2		
24					12	6.6	14	12	10	8.7		
25				20	10	6.6	13	8.0	1.5	9.8		
26				18	3.7	5.5	12	11	1.6	12		
27				18	1.6	8.8	11	18	3.1	10		
28				15	3.2	11	7.9	18	4.5	11		
29				12	5.0	15	4.0	17	5.1	9.0		
30				27	12	14	4.3	13	4.1	8.4		
31					13		9.9	9.9		9.5		
Average				18.3	10.7	9.0	7.9	10.7	8.8	8.8	8.6	
Runoff in acre-feet				220	660	540	480	660	520	540	340	

TABLE 7—Continued

TAISON, 1952

Location: SW ¼, Sec. 11, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2:

(Daily mean flow in second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1					9.1	0	0	5.7	10	1.5	2.8	
2					9.4	0.7	0.5	3.9	21	3.3	11	
3					2.6	2.5	2.4	0.8	22	4.8	11	
4					4.0	5.7	0	0	25	1.5	6.0	
5					6.1	8.6	0	1.3	21	0	3.3	
6					4.4	7.3	0	4.0	15	0.2	3.0	
7					1.9	5.6	0	6.8	6.3	8.7	4.0	
8					6.8	3.9	0.2	7.1	6.3	8.3	2.6	
9					0.4	2.1	4.3	14	14	8.3	2.1	
10					6.1	4.2	7.8	17	12	0	2.2	
11					3.1	0.9	4.6	9.8	14	0	2.1	
12					7.3	0	1.8	12	12	11	6.5	
13					1.3	12	1.0	13	8.8	5.3	3.0	
14					0	13	0	9.9	7.7	8.6	0.2	
15					0	3.1	0.9	11	6.7	9.7	5.3	
16					0	0	4.8	14	3.2	11	9.5	
17					0	0.5	4.5	12	6.3	10	11	
18					0	0.4	0.7	4.7	7.3	7.1	13	
19					1.3	0	0.6	5.2	18	0.9	2.5	
20					3.4	0	7.0	0.9	21	7.5	0.5	
21					8.4	2.0	11	0.8	21	7.5		
22				1.6	14	7.3	5.0	3.2	14	8.0		
23				10	4.7	10	0.2	0.6	19	9.2		
24				5.9	1.1	13	2.3	2.9	10	6.7		
25				9.6	0	11	9.7	10	7.3	9.9		
26					0.7	9.5	1.1	3.1	5.2	10		
27					0	9.3	3.9	0.9	4.5	7.4		
28				11	0	11	0.4	0.8	0.3	9.4		
29				6.9	0	12	0	3.7	2.0	5.9		
30				11	0.5	5.3	0	2.4	2.8	5.7		
31					0.2		0.9	3.5		3.6		
Average				8.0	3.1	5.4	2.4	5.9	11.5	6.2	5.0	
Runoff in acre-feet				140	180	320	150	360	680	380	200	

TABLE 7—Continued

WEBER, 1952

Location: NE ¼, Sec. 27, T. 2 N., R. 6 E., M. D. B. & M. Station number on Plate 2:

(Daily mean flow in second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1					4.3	6.1	4.1	1.2	4.1	4.8	11	
2					3.0	9.2	2.0	2.0	2.4	5.3	5.6	
3					4.1	10	1.5	2.3	2.1	4.7	7.9	
4					4.6	12	1.9	2.0	2.5	2.9	8.7	
5					3.3	13	1.2	0.4	3.9	2.4	5.8	
6					1.9	15	1.1	1.3	2.1	3.4	4.4	
7					2.4	6.2	1.5	1.5	1.1	5.8	5.9	
8					2.4	5.9	3.1	2.1	2.8	8.9	2.3	
9					1.8	6.3	1.0	1.5	2.9	12	1.4	
10					1.8	5.1	0.7	1.0	2.5	8.0	4.0	
11					2.9	2.7	2.0	2.1	1.2	6.7	2.7	
12					3.1	3.6	1.3	1.0	2.4	5.9	2.3	
13					4.5	5.2	1.2	1.2	7.3	6.2	3.1	
14					2.9	4.6	0.7	1.8	6.1	5.3	8.7	
15					2.8	2.4	0.8	3.8	6.8	4.1	9.4	
16					9.9	1.7	1.7	3.2	9.6	5.5	8.9	
17					4.2	2.2	1.2	2.7	14	5.2	7.3	
18					4.4	1.2	0.7	2.2	10	12	6.1	
19				0	2.2	1.8	0.7	4.0	6.5	7.4	4.1	
20				2.1	1.2	2.4	1.5	4.8	4.3	6.6	8.0	
21				1.0	1.3	2.4	2.0	4.5	4.5	3.0		
22				0	0.4	2.0	1.9	3.5	5.0	2.7		
23				1.1	0	2.2	1.6	3.7	7.2	5.7		
24				0.4	0	4.4	0.9	3.1	8.2	4.4		
25				2.4	0.3	3.2	1.1	1.9	6.6	5.1		
26				5.2	3.0	5.2	1.1	1.9	5.1	6.6		
27				6.2	0.4	8.3	0.7	2.7	5.3	7.2		
28				5.8	2.3	7.7	1.2	3.0	7.6	7.5		
29				5.6	3.5	6.3	0.2	4.3	9.5	8.4		
30				6.3	5.6	5.8	0.2	4.3	4.6	8.6		
31					3.5		0.4	3.0		8.9		
Average				3.0	2.7	5.5	1.3	2.5	5.3	6.2	5.9	
Runoff in acre-feet				70	170	320	80	150	320	380	230	

TABLE 7—Continued

BRACK, 1952

Location: SE ¼, Sec. 28, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 7

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							6.4					
2						2.2			0.5	4.5		
3									7.2	0.7	*0.5	
4						1.2		7.1	10.0			
5									7.5		*0.5	
6						0		6.7		0	*0.5	
7						0	8.4			4.1	0	
8								9.1	0.9	1.6		
9						0	*4.0			*0.5		
10						0			0.9		0	
11							10.5		6.5			
12						0		0	7.0		0	
13						*1.0		0			0	
14										3.0	0	
15						4.1		2.0	0	2.3		
16						0	0.9		0	*0.5		
17										*0.3		
18							0.3	0	0			
19						6.8			5.5			
20							*1.0	6.4		*0.3		
21							0		6.2	*0.3		
22					3.1			9.6		0		
23						0			5.0	0		
24						6.6			4.3	0		
25						8.0	6.7	0	6.4			
26					*1.0	4.1			3.1			
27						8.7				0		
28					0		*2.0		15.5	1.1		
29							6.9	7.9	0	*0.5		
30						4.9				*0.5		
31										0		

* Estimated.

TABLE 7—Continued

CALDONI, NORTH, 1952

Location: NW ¼, Sec. 14, T. 3 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 8

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							0	*2.0				
2						7.9	5.3		*0.5	0		
3							5.7		0	*4.0	0	
4						*7.0		0	0			
5						*3.0		0	5.2		0	
6					*3.0	*1.0		4.1		0	0	
7					*3.0	0		*3.0		0	0	
8							*1.0	2.9	0	0		
9					*2.0	0	*1.0			0		
10						0	0		0	0	0	
11							*1.0	3.9	0			
12						0		*0.5	6.1		0	
13						0		*1.0			0	
14					4.7		6.7	*0.5		0	0	
15					4.1	0	8.0	1.3	0	2.7		
16					*3.0	0	0		0	4.8		
17						0	0		0	*1.0	0	
18							0	*0.5	*0.5		0	
19					0.5	4.5		*0.5	0		0	
20					0	4.4	0	0		0	0	
21					0		0	0	0	0		
22							*2.0	6.4		0		
23					*3.0				0	0		
24						*1.0	0	7.3	5.7	0		
25						0	*3.0	0	7.9			
26					0	0	1.1	0	0			
27					0	0				0		
28					0		0	2.2	0	0		
29					0		*0.5	6.9	0	0		
30				3.6		0			0	0		
31							*1.5			0		

Estimated.

TABLE 7—Continued

CALDONI, SOUTH, 1952

Location: NW ¼, Sec. 14, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 9

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							0	0				
2						0	0.5		4.3	0		
3							0		2.2	0		
4						1.8		0	0			
5					4.8	0		4.2	0			
6						4.2		0		2.1		
7					2.2	3.0	12	0		0.9		
8							6.7	0	9.7	3.5		
9					0	5.7	6.5			0.9		
10						3.2	0		5.7	0		
11							0.6	1.8	0			
12					1.6	1.4		0	0			
13						1.7		0				
14					0		0	1.3		0		
15					4.9	1.7	2.2	1.4	5.8	1.4		
16					0	2.7	0		4.9	3.1		
17						1.9	0		0	1.7		
18							0	0	8.9			
19					4.9	0		0	0			
20					4.9	2.3	7.1	0		0		
21					0		0.5	0	10	0		
22							0	0		0		
23					0	6.0			0			
24						4.0	0	4.5	0			
25						5.0	0	7.4	6.7			
26					0	0	0	1.9	5.8			
27					0	2.0						
28					3.3		0.7	9.7	5.7			
29					4.4		1.5	0.7	0			
30				5.4		0			0			
31							0					

TABLE 7—Continued

COTTA No. 2, 1952

Location: SE ¼, Sec. 34, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 10

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							*0.5	0				
2					0.8	0	*0.5		0	0		
3							0		0	0	0	
4						0		0	0			
5					0	0		*0.2	0		0	
6						*0.8		1.3		0	0	
7						*0.8	0	0		0	0	
8							0.8		0	0		
9						0	0.5					
10						0	0		0	*3.0	0	
11							0					
12					0			0	0		0	
13						*0.5		0			0	
14						*0.5	0			*0.3	0	
15					*0.5		0		*0.7	0		
16						0	0		*0.3	*0.8		
17						*0.3	0		0	0	0	
18							0				0	
19								0	0		0	
20					0	*0.5	1.2	0		0	0	
21							0	0	0	0		
22				0	1.0		0.9	1.7		0		
23					0	0			0	0		
24						*0.3	0	*0.8	0			
25				0		*0.5	0	0	0			
26					0		0.3	0				
27					0	0				0		
28					0		0	0	0	0		
29					0		0	0.5		0		
30						0				5.7		
31							0			*0.3		

* Estimated.

TABLE 7—Continued

COTTA No. 3, 1952

Location: SW ¼, Sec. 34, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 11

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							0	0				
2						0	0		0	0		
3									0	0	0	
4						0		0	0			
5								0	0		0	
6						0		7.5		0	0	
7						0	0	0		0	0	
8									0	0		
9						0						
10									0		0	
11							0					
12					0			0	0		0	
13						0		0			0	
14							0	6.2			0	
15					0		0		*1.0	0		
16						0	0		0	0		
17						0	0		0	0	0	
18							0				0	
19								0	0		0	
20							0	0		0	0	
21							0	0	0	0		
22				*0.3	0		6.6			0		
23						0			0	0		
24						0	0	0	0	0		
25						0	0	0	0			
26					0			0				
27						0				0		
28							0	0	0	0		
29								0		0		
30						0				4.0		
31							3.1			0		

* Estimated.

TABLE 7—Continued

COTTA No. 4, 1952

Location: SW ¼, Sec. 34, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 12

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							0	0				
2						0	0		0	0		
3									0	0	0	
4						0		0	0			
5								0	0		0	
6						0		6.4		0	0	
7						0	0	0		0	0	
8									0	0		
9						0						
10									0		0	
11							0					
12					0			0	0		0	
13						0		0			0	
14							0	2.5			0	
15					0		0		0	0		
16						0	0		0	0		
17						0	0		0	0	0	
18							0				0	
19								0	0		0	
20							0	0		0	0	
21							0	0	0	0		
22				1.1	0		5.1			0		
23						0			0	0		
24				1.9		0	0	0	0	0		
25				1.9		0	0	0	0			
26					0			0				
27						0				0		
28				1.2			0	0	0	0		
29								0		0		
30						0				3.1		
31							4.0			0		

TABLE 7—Continued

COTTA No. 6, 1952

Location: NW ¼, Sec. 3, T. 3 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 13

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							0					
2						0	*1.0		0	0		
3							*2.0		0	*1.0	0	
4						0		*0.5				
5						0		0	0		0	
6						0		0		0	0	
7						6.4	0	0		0	0	
8							0	3.8	0	0		
9						*0.5	*0.5					
10						0			0		0	
11							0		0			
12						0		0	*2.0		0	
13						0		0			0	
14					5.5		0			3.0	0	
15					5.3	0	0	0	0	2.4		
16						0				0		
17						0	5.8		0	4.9	0	
18							*0.5	4.4	2.7		0	
19						*1.0			2.1		0	
20					0.9	*1.0	9.3	0		0		
21					0.9		0	0	0	0		
22							0			0		
23					0	*0.5			0	3.8		
24						*0.5	0	8.0		3.1		
25						*0.5	0	0	0			
26												
27					0	0				0		
28					0		0	0		0		
29					*3.0		0	*0.5		0		
30						0				0		
31										0		

* Estimated.

TABLE 7—Continued

JOHNSON, 1952

Location: SW ¼, Sec. 34, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 14

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							1.1	1.1				
2						0	0.6		19	0.6		
3									0	0.6	0.6	
4						*1.0		3.8	1.1			
5					0.6			4.6	0.6		1.1	
6						1.5				1.1	0.6	
7						1.5	*0.3	1.0		4.6	1.1	
8									0.6	0.6		
9												
10						1.1			0.6		1.1	
11							5.5					
12					0			4.6	0.8		0.6	
13						0.5		1.6			2.3	
14							0.6					
15					0.6		0.6			0.6		
16				5.6		*0.5	1.6		2.6	1.6		
17						3.3	0.6		0.6	2.3		
18							0.6				1.1	
19								1.6	0.6			
20							0	1.1		2.3	0	
21							*0.5	1.1	0.3	2.3		
22				*0.1	0.5					4.6		
23						0.5			3.3	0.6		
24						2.8	0.6	1.6	3.8			
25				0		2.8	0.6	3.0	0.6			
26					0			25				
27						1.1				0.6		
28							0.6	1.1	0.6	3.0		
29								1.1		3.0		
30						1.6						
31										0.6		

* Estimated.

TABLE 7—Continued

KETTLEMAN, 1952

Location: NW ¼, Sec. 31, T. 3 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 15

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1								0.6				
2									1.1	0		
3									0	*0.5	0	
4								0.9				
5								*0.2	0		0	
6								*0.3		0	0	
7								0			0	
8								1.6	0	0		
9										0		
10									0	0	0	
11								0.9				
12								0.7	0		0	
13								0.9			0	
14										0	0	
15								0	0	0		
16										0		
17									0.8	*0.5	0	
18								0			0	
19								0	*0.5		0	
20								0		0	0	
21									0	0		
22								0.6		0		
23									0.6	0		
24								0	0			
25								0				
26								0	0			
27							0.6			*0.5		
28							0.7		0	0		
29							*0.5	0	*0.5	0		
30										0		
31							1.1			0		

* Estimated.

TABLE 7—Continued

NORTH BEAR CREEK, 1952 *

Location: NW ¼, Sec. 8, T. 2 N., R. 6 E., M. D. B. & M. Station number on Plate 2: 16

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1					**2.0		13	4.9				
2					**2.0	4.5	7.5		5.0	2.2		
3							8.9		5.5	0.7	2.0	
4						6.5		5.9	6.4			
5						**5.0		5.1	6.1		0	
6					1.6	5.6		5.7		0.8	0	
7					0	2.9	6.1	8.0		3.2	0	
8							6.5	4.8	7.2	1.7		
9					0	6.1	4.6			1.3		
10						5.0	5.8		11	0	0	
11							5.0	6.9	8.1			
12						1.2		6.3	7.9		0	
13						7.5		6.4			0	
14							7.9	6.3		0	0	
15						16	5.1	4.1	8.6	0		
16						13	5.7		9.5	0		
17						16	7.1		7.4	0	4.0	
18							5.7	6.9	8.0		3.0	
19						8.3		10	7.3		0	
20					1.7	10	6.7	6.2		0	0	
21					1.7		4.2	4.8	14	0		
22							6.5	3.9		**0.5		
23					3.9	7.4			6.7	0		
24						8.3	7.0	5.1	8.5	2.1		
25						6.9	5.0	5.7	8.8			
26						7.3	4.6	4.8	14			
27					3.8	5.7				2.3		
28					2.0		6.6	4.5	9.3	**0.5		
29					3.9		6.4	7.0	7.3	0		
30						18			6.7	0		
31							4.1			0		

* Net flow (North Bear Creek less Bear Creek at Highway 99 and Aron Cannery Waste).
** Estimated.

TABLE 7—Continued

SMITH-RIDDELL, 1952

Location: SE ¼, Sec. 3, T. 3 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 17

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							0					
2						*2.0	0		0	0		
3							0		0	0	0	
4						1.8		2.1				
5						*1.0		0.4	0		1.2	
6						2.0		0		0	0	
7						0	0	0		0	0	
8							0	0	0	0		
9						0	0					
10						0			0		0	
11							0		0			
12						0		0	0		0	
13						0		0			0	
14					2.6		0			0	0	
15						0	0	1.1	0	0		
16						*1.0				0		
17						*1.5	0		0	0	0	
18							0	0	1.8		0	
19					0	0			0		0	
20					0	0	0	1.5		0	0	
21					0		0	*0.5	0	0		
22					0		0			0		
23					0	0			0	0		
24						0	0	0		0		
25						0	0	0	0			
26												
27					0	0				0		
28					0		0	1.7		0		
29					0		0	1.2		0		
30						0				0		
31										0		

* Estimated.

TABLE 7—Continued

SOUTH BEAR CREEK, 1952

Location: SW ¼, Sec. 9, T. 2 N., R. 6 E., M. D. B. & M. Station number on Plate 2: 18

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1					3.7		*1.5	*0.5				
2					*4.0		*1.0		2.8	2.4		
3							*0.5		2.3	4.7	0	
4								*0.5	2.4			
5						0		2.7	3.7		0	
6					*4.0			4.3		1.7	0	
7					0	*2.0	*0.5	4.5		*0.5	0	
8							*0.5	4.8	3.6	*0.5		
9					*2.0					0		
10						*3.0	*0.5		4.1	0	0	
11							*0.5	5.2	3.1			
12						*3.0		7.0	3.1		0	
13								5.3			0	
14					*1.5		*0.5	5.1		0	0	
15						*3.0	*0.5	5.6	3.0	0		
16				0	*2.5				3.6	0		
17				0		*2.0			3.8	0	0	
18							*1.0	3.7	4.3		0	
19					0	*3.0		3.8	3.7		0	
20							*1.0	2.8		0	0	
21					0		*1.0	1.9	2.4	0		
22								3.3		0		
23					*2.0	*2.0			4.8	0		
24						*2.0	0	3.3	3.2	0		
25							*0.5	3.4	3.5			
26						*2.0	*0.5	4.4	*3.5			
27					*1.5	*1.5				0		
28					0		*0.5	3.3	4.2	0		
29				*5.0	*1.0		0	4.1	8.4	0		
30				*5.0		*2.0			5.3	0		
31							*2.0			0		

* Estimated.

TABLE 7—Continued

SOUTHERN PACIFIC, 1952

Location: NW ¼, Sec. 26, T. 2 N., R. 6 E., M. D. B. & M. Station number on Plate 2: 19

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							0	0.3				
2							0.2		0.2	0.8		
3							0		0.3	0.8	0	
4								0.3	0.3			
5								0.5	0.3		0	
6								0.3		0.3	0	
7							0.2	0.2		0.2	0	
8							0.3	0.2	0	0.2		
9										0		
10							0.3		0.2	0	0	
11							0.3		0.2			
12								0.2	0.2		0	
13								0.3			0	
14							0.3	0.5		0	0	
15							0.5	0.3	0.5	0		
16									0.8	0		
17							0		0.8	0	0	
18									0.5		0	
19								0.2	0.8		0	
20							0	0.3		0	0	
21						0.2	0.3	0.5	0			
22						0.3			0			
23						0.5		0.3	0			
24						0.5	0.5	0.3	0.3	0		
25						0.5	0.5		0.3			
26						0.5		0.1				
27										0		
28								0.2	0.5	0		
29								0.2	0.5	0		
30						0				0		
31							0.3			0		

TABLE 7—Continued

STATE FARM, 1952

Location: SW ¼, Sec. 29, T. 2 N., R. 6 E., M. D. B. & M. Station number on Plate 2: 20

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1					0		0	0.6				
2					0		0		0	0		
3							0		0	0	0	
4								0	0			
5						0		0	0		0	
6					0			0		0	0	
7							0	0		0	0	
8							0	0	0	0		
9					0					0		
10						0	0		0	0	0	
11							0		0			
12						0		0	0		0	
13								0			0	
14							0	4.8		0	0	
15						0		0.9	0	0		
16					0				0	0		
17							0		0	0	0	
18							0		0		0	
19					0	0		0	0		0	
20						0	0	0		0	0	
21					0		0	0	0	0		
22							0			0		
23					0	5.5			0	0		
24						0	0	0	0	0		
25						0	*1.0		0			
26						0	0	0	0			
27					2.6	0				0		
28								0	0	0		
29					0			0	0	0		
30						0			0	0		
31							4.2			0		

* Estimated.

TABLE 7—Continued

TAISON (THORNTON ROAD), 1952

Location: NW ¼, Sec. 14, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 21

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							0.3	0.8				
2						*0.5	1.7		*0.3	0		
3							0.3		*0.1	*0.3	2.3	
4						*0.5		0.3	0.8			
5						*0.5		0.2	1.0		0.7	
6						*0.8		0.2		*0.2	0.5	
7						*1.0	0.3	3.1		0	*0.5	
8							3.5	0.7	0	*0.2		
9						3.5	1.0			*0.5		
10						*1.5	1.0		0	*0.5	1.1	
11							1.8		*0.2			
12						*0.5		0.4	1.4		*0.5	
13						*0.5		0.2			*0.5	
14							0.2	1.1		*0.3	*0.5	
15						0	0.7	0.3	*0.2	1.4		
16						0	0.4		*0.2	1.5		
17						0	0.4		*0.2	1.1	*0.5	
18							1.1	1.3	1.0		*0.3	
19						*1.5		0.5	1.5		*0.2	
20						*0.5	0.1	*0.3		3.5	0	
21					*1.0		0.3	1.3	*0.3	1.9		
22					3.7		0.4	1.9		1.1		
23					*0.5	*0.8	0.5		*0.2	2.0		
24						*1.5		1.0	*0.3	1.9		
25							0.6	3.0	*0.2			
26					*0.5	*0.8	0.5	*0.1	0			
27					0	*0.5				1.5		
28					0		0	3.5	0	0.9		
29					*1.0		0	3.8	0	0.7		
30						0.4			0	*0.5		
31							0.5			*0.5		

* Estimated.

TABLE 7—Continued

TAISON (WESTERN PACIFIC RAILROAD), 1952

Location: NW ¼, Sec. 14, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 22

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1					*3.0		6.7	2.6				
2									2.1	5.5		
3							5.9		3.9		3.3	
4								1.2	3.0			
5					*0.7	3.3		5.0	2.7		3.5	
6						3.6		5.1		2.1	4.0	
7						2.7		3.6		2.2	3.7	
8					5.5			*2.0	2.8	1.9		
9					*3.0	1.2	5.3			1.2		
10						2.9	2.8		3.3	3.2	2.6	
11							2.2		2.6			
12					0.7	2.4		2.8	3.0		2.3	
13					1.2	5.4		4.7			2.1	
14							1.5			2.8	3.8	
15					2.8		2.9	2.2	2.5	2.5		
16					3.0	2.4	5.6		3.6	9.1		
17						6.5	3.4		5.0	4.6	5.0	
18							5.6	1.2	5.5		3.0	
19					6.4	6.7		2.2	3.8		2.5	
20					6.0		4.9	2.4		3.2	0	
21					2.7		1.6	4.6	1.4	3.2		
22					1.4		2.9	6.3		2.7		
23					2.3	0.5			2.6	2.9		
24							6.7	2.7	2.6	2.8		
25						2.2	2.7	*1.0	2.5			
26					1.4		2.8		3.7			
27					2.9					2.5		
28					3.2		1.9		2.3	2.2		
29					5.8			2.6	2.9	2.9		
30						3.4			3.8	2.7		
31							2.9			4.2		

* Estimated.

BLE 7—Continued

THOMPSON-FOLGER, 1952

ocation: SE ¼, Sec. 21, T. 4 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 23

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							0.9	0.0				
2						3.3	2.2		1.1	1.3		
3							1.2		1.1	0.6	0	
4						3.7		0.4				
5									0		0	
6						0				0	0	
7					2.3	0	2.6	0		1.2	0	
8					2.5		2.7		0	0		
9						3.4	2.6					
10						2.0	2.4		0		0	
11							2.3		0			
12					3.2			0	0		0	
13						0					0	
14							2.5				0	
15					3.0		3.4	1.6	1.0	0		
16						2.1	0.8			0		
17						3.1	2.6			0		
18							1.7	1.6			0	
19						3.3		1.5	1.5		0	
20							0	1.6		0	0	
21							0	0	0	0.5		
22					0		0	0.8		*0.5		
23						0			0			
24						0	1.8	2.6	0			
25				2.0		0	3.4	0.9	0			
26					3.2		1.1	0.8	0			
27						1.5				0		
28					2.9		1.3	0	0	0		
29							1.7	0	0	0		
30						3.2			0	0		
31							0			0		

*Estimated.

BLE 7—Continued

UPLAND No. 2, 1952

ocation: NE ¼, Sec. 10, T. 3 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 24

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							11	11				
2						*3.0	11		9.1	11		
3							8.9		17	7.2	*1.5	
4						3.6		14	16			
5					6.3	*3.0		13	12		6.2	
6						6.3		8.3		9.3	6.5	
7					*6.0	9.9	12	10		11	11	
8					3.2		15	4.8	3.5	8.5		
9					4.3	11	7.3			5.4		
10						8.0	8.8		9.2	4.0	9.9	
11							*1.0	7.9	14			
12					6.7	15		7.0	17		3.9	
13						13		12			2.9	
14								14		4.4	6.3	
15					8.2	7.0	11	7.6	2.4	8.9		
16						8.3	12		*2.5	9.6		
17						7.9	11			12	*3.0	
18							15	5.2	*1.0		2.4	
19					9.6	13		3.1	1.2		*1.5	
20					9.1	7.5	3.7	7.9		1.6	0	
21					5.3		10	13	2.8	1.2		
22							3.2	15		0.9		
23					*4.0	9.2			4.3			
24						3.7	12	20	6.8			
25						3.5	13	19	10			
26					9.2	*4.0	9.2	7.6	11			
27					9.4	6.0				*0.5		
28					13		7.4	2.3	6.5	*0.8		
29					15		4.4	10	5.0	*0.5		
30						13			5.6	*2.0		
31							8.5			*1.5		

*Estimated.

TABLE 7—Continued

UPLAND No. 3, 1952

Location: SW ¼, Sec. 11, T. 3 N., R. 5 E., M. D. B. & M. Station number on Plate 2: 25

(In second-feet)

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1							2.1	2.6				
2						8.5	3.0		2.0	*0.3		
3							1.6		0.9	2.1	1.0	
4						5.8		*0.3	*0.5			
5						3.5		1.0	*0.3		*1.0	
6						*0.5		2.0		*0.5	*0.8	
7					1.4	1.0	0.4	3.0		2.1	1.2	
8							1.4	3.2	4.5	3.4		
9					2.8	1.2	5.1			4.2		
10						1.3	3.0		0.9	2.7	1.2	
11							4.1	15	0.5			
12					1.6	2.1		11	0.9		2.0	
13						1.3		7.1			2.8	
14					0.9		0.9	6.2		3.7	4.0	
15						0.9	0.9	5.4	0	0.8		
16						2.5	0.9			*0.5		
17						1.1	1.6		0	*0.3	*1.0	
18						*2.0	1.0	3.9	2.1		*1.5	
19					2.2	*2.0		5.5	1.9		*0.5	
20					0		4.2	6.0		1.0	0	
21					0.5		3.9	5.5	6.1	*0.5		
22							6.2	1.3		*0.8		
23					2.6	6.6			4.9	*1.0		
24							2.8	0.8	*1.0	*0.5		
25						3.7	*2.5	0.4	*0.5			
26					1.6			1.5				
27					2.2	4.5				*0.8		
28					2.2		1.7	2.5	3.6	*0.8		
29					1.6		1.2	4.5	3.0	*0.8		
30						4.8			*0.5	*0.8		
31							3.3			*0.8		

* Estimated.

APPENDIX E

DEPTHS TO GROUND WATER AT MEASUREMENT WELLS IN SAN JOAQUIN AREA

(On File With the Division of Water Resources)

APPENDIX F

RECORDS OF PARTIAL MINERAL ANALYSES OF GROUND WATER IN SAN JOAQUIN AREA

(Water Samples Collected by the Division of Water Resources)

RECORDS OF PARTIAL MINERAL ANALYSES OF GROUND WATER IN SAN JOAQUIN AREA

(Water samples collected by the Division of Water Resources)

Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10⁶ at 25° C.	Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10⁶ at 25° C.
T5N/R5E-33L1	5/18/50	0.93	476	T4N/R6E-36A2	5/19/50	0.59	348
T5N/R5E-33L1	8/ 8/50	0.73	428	T4N/R7E-7C1	9/ 1/49	0.56	343
T5N/R7E-31M1	5/23/50	0.68	301	T4N/R7E-8B1	5/13/49	0.28	186
T4N/R5E-3F1	5/15/50	0.31	401	T4N/R7E-8B1	7/ 7/49	0.28	183
T4N/R5E-3L1	5/15/50	0.82	428	T4N/R7E-8B1	9/ 1/49	0.28	186
T4N/R5E-4H1	5/10/49	0.84	352	T4N/R7E-8R1	5/23/50	0.45	192
T4N/R5E-4H1	7/11/49	0.56	400	T4N/R7E-8R1	8/ 8/50	0.42	214
T4N/R5E-4H1	9/ 5/49	0.28	386	T4N/R7E-9D1	5/13/49	0.28	236
T4N/R5E-4H1	5/15/50	0.48	345	T4N/R7E-9D1	7/ 7/49	0.28	193
T4N/R5E-4H1	8/ 8/50	0.39	314	T4N/R7E-9D1	9/ 1/49	0.28	186
T4N/R5E-5A1	5/18/50	15.75	1,130	T4N/R7E-10C1	5/13/49	0.56	414
T4N/R5E-8H1	5/10/49	27.89	3,140	T4N/R7E-10C1	7/ 7/49	1.41	379
T4N/R5E-8H1	9/ 7/49	24.79	2,570	T4N/R7E-14B1	5/13/49	0.84	300
T4N/R5E-10D2	5/10/49	0.56	372	T4N/R7E-14B1	7/ 7/49	0.84	293
T4N/R5E-10D2	7/19/49	0.28	364	T4N/R7E-14B1	9/ 7/49	0.28	272
T4N/R5E-12P1	5/15/50	0.87	499	T4N/R7E-15A2	5/13/49	0.28	179
T4N/R5E-13D1	5/10/49	1.41	472	T4N/R7E-15A2	7/ 7/49	0.56	183
T4N/R5E-13D1	7/11/49	1.41	472	T4N/R7E-15A2	9/ 7/49	0.28	172
T4N/R5E-13R1	9/ 1/49	0.28	372	T4N/R7E-15M2	5/13/49	0.84	314
T4N/R5E-13R2	7/11/49	2.53	858	T4N/R7E-15M2	7/ 7/49	0.56	269
T4N/R5E-13R2	5/15/50	2.53	917	T4N/R7E-16M1	5/17/50	0.53	220
T4N/R5E-23R1	5/10/49	1.69	696	T4N/R7E-18H1	5/12/49	0.56	250
T4N/R5E-23R1	7/13/49	1.69	672	T4N/R7E-19D2	5/19/50	0.31	191
T4N/R5E-24C1	5/10/49	1.41	500	T4N/R7E-19D2	8/ 8/50	0.56	271
T4N/R5E-24H2	5/15/50	1.58	552	T4N/R7E-19J2	5/13/49	0.56	286
T4N/R5E-24H2	8/ 8/50	1.44	671	T4N/R7E-19J2	7/20/49	0.84	400
T4N/R6E-11M4	5/23/50	0.39	287	T4N/R7E-19M1	5/12/49	0.84	372
T4N/R6E-12D1	5/13/49	0.28	214	T4N/R7E-19M1	7/13/49	1.13	350
T4N/R6E-12H2	7/ 7/49	0.84	268	T4N/R7E-19P1	5/17/50	----	190
T4N/R6E-15C2	5/12/50	0.62	258	T4N/R7E-20B1	5/17/50	0.22	174
T4N/R6E-16P1	5/10/49	0.56	228	T4N/R7E-20H1	5/13/49	0.28	186
T4N/R6E-17E1	5/12/50	1.35	494	T4N/R7E-23C2	5/13/49	1.13	414
T4N/R6E-17F1	5/15/50	1.07	416	T4N/R7E-23C2	7/ 7/49	2.25	557
T4N/R6E-17F1	8/ 8/50	1.01	357	T4N/R7E-26A1	5/13/49	0.56	286
T4N/R6E-18F1	5/10/49	1.13	607	T4N/R7E-26A1	7/ 7/49	0.56	250
T4N/R6E-18F1	7/20/49	1.13	557	T4N/R7E-26A1	9/ 7/49	0.28	243
T4N/R6E-18Q1	5/15/50	1.18	623	T4N/R7E-28M1	5/12/49	0.56	300
T4N/R6E-18Q1	8/ 8/50	1.07	428	T4N/R7E-28M1	7/ 7/49	1.41	536
T4N/R6E-19A1	5/10/49	1.13	607	T4N/R7E-29P1	7/ 7/49	0.84	328
T4N/R6E-19M2	5/22/50	1.21	623	T4N/R7E-30H1	5/19/50	1.29	457
T4N/R6E-20H1	5/10/49	0.56	536	T4N/R7E-30J1	5/17/50	0.79	313
T4N/R6E-20H1	5/12/50	0.76	458	T4N/R7E-31F1	5/19/50	0.84	342
T4N/R6E-21H1	5/19/50	0.56	279	T4N/R7E-32B1	5/12/49	0.28	357
T4N/R6E-21H1	8/ 8/50	0.51	428	T4N/R7E-33L1	5/12/49	1.13	600
T4N/R6E-22C5	5/19/50	1.41	471	T4N/R7E-33L1	7/ 7/49	0.56	400
T4N/R6E-22C5	8/ 8/50	1.29	457	T3N/R5E-13K1	5/11/49	0.56	464
T4N/R6E-22F1	5/10/49	0.56	536	T3N/R5E-13K1	7/ 8/49	0.28	414
T4N/R6E-22L1	5/10/49	1.41	400	T3N/R5E-13K1	9/21/49	0.28	443
T4N/R6E-22L1	7/11/49	1.97	614	T3N/R5E-14C1	5/11/49	0.84	374
T4N/T6E-22L1	9/ 1/49	1.41	528	T3N/R5E-14C1	7/ 9/49	0.84	365
T4N/R6E-23A2	5/12/50	1.38	464	T3N/R5E-14C1	9/ 9/49	0.28	286
T4N/R6E-23E1	5/12/49	1.13	457	T3N/R5E-14C1	5/23/50	1.07	394
T4N/R6E-23E1	7/11/49	1.13	443	T3N/R5E-14C1	8/ 9/50	0.96	286
T4N/R6E-23E1	9/ 7/49	0.84	414	T3N/R6E-2K3	5/12/49	1.13	772
T4N/R6E-23N1	5/19/50	1.63	485	T3N/R6E-2K3	7/ 8/49	1.41	672
T4N/R6E-24R1	5/23/50	1.91	613	T3N/R6E-2K3	9/ 5/49	1.13	614
T4N/R6E-25F1	5/10/49	1.13	608	T3N/R6E-3D3	5/23/50	0.17	187
T4N/R6E-25F1	7/20/49	0.84	364	T3N/R6E-3K1	5/12/49	0.56	557
T4N/R6E-25R1	5/19/50	0.45	242	T3N/R6E-3K1	7/11/49	0.84	536
T1N/R6E-25R1	8/ 8/50	0.90	428	T3N/R6E-3Q1	5/18/50	1.58	710
T4N/R6E-26N1	5/19/50	0.20	251	T3N/R6E-4B2	5/22/50	0.62	508
T4N/R6E-30R2	5/12/50	1.91	532	T3N/R6E-4E2	5/22/50	0.79	522
T4N/R6E-31A1	5/11/49	1.13	523	T3N/R6E-5E2	5/18/50	----	342
T4N/R6E-31A1	7/11/49	0.84	657	T3N/R6E-5E2	8/18/50	0.20	----
T4N/R6E-31J1	5/18/50	0.42	390	T3N/R6E-5P1	5/11/49	0.28	290

RECORDS OF PARTIAL MINERAL ANALYSES OF GROUND WATER IN SAN JOAQUIN AREA—Continued

(Water samples collected by the Division of Water Resources)

Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10^6 at 25° C.	Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10^6 at 25° C.
T3N/R6E-5P1	7/19/49	0.56	357	T3N/R6E-32H1	5/19/50	0.87	332
T3N/R6E-6C1	5/18/50	1.07	349	T3N/R6E-34J1	5/12/49	0.56	357
T3N/R6E-6C1	8/ 8/50	0.62	343	T3N/R6E-34J1	7/ 8/49	0.56	357
T3N/R6E-7M1	5/11/49	0.84	428	T3N/R6E-34J1	9/12/49	0.28	228
T3N/R6E-7M1	7/ 8/49	1.13	407	T3N/R6E-36E1	5/15/50	0.87	503
T3N/R6E-8F1	5/12/50	0.56	398	T3N/R6E-36H1	5/15/50	0.73	422
T3N/R6E-8R1	5/22/50	0.93	647	T3N/R6E-36H1	8/ 9/50	0.84	428
T3N/R6E-8R1	8/ 9/50	1.01	628	T3N/R6E-36J2	5/15/50	0.45	327
T3N/R6E-9D1	5/11/49	0.28	257	T3N/R6E-36K1	5/15/50	0.51	324
T3N/R6E-9D1	7/ 8/49	0.28	268	T3N/R6E-36K1	8/ 9/50	0.37	246
T3N/R6E-9Q1	5/22/50	1.63	715	T3N/R6E-36M3	5/15/50	0.96	477
T3N/R6E-10N5	5/19/50	1.27	980	T3N/R7E-5E4	5/13/49	0.28	357
T3N/R6E-10P2	5/18/50	1.01	770	T3N/R7E-5E4	7/ 7/49	0.56	386
T3N/R6E-10P2	8/ 9/50	0.96	643	T3N/R7E-6N1	5/19/50	1.24	547
T3N/R6E-13G2	5/15/50	2.14	942	T3N/R7E-9L1	5/17/49	0.28	286
T3N/R6E-13M1	5/15/50	1.01	613	T3N/R7E-9L1	7/13/49	0.56	386
T3N/R6E-14D1	5/22/50	1.10	474	T3N/R7E-10R1	5/17/49	1.13	329
T3N/R6E-14N2	5/22/50	1.15	689	T3N/R7E-10R1	7/ 6/49	1.41	386
T3N/R6E-17A2	5/22/50	1.77	780	T3N/R7E-11C1	5/17/49	0.56	179
T3N/R6E-17H1	5/11/49	1.69	714	T3N/R7E-11G1	7/ 6/49	1.13	364
T3N/R6E-17H1	7/ 8/49	1.41	264	T3N/R7E-12M1	5/17/49	0.28	179
T3N/R6E-17M1	5/19/50	1.32	455	T3N/R7E-12M1	7/ 6/49	0.56	176
T3N/R6E-17R1	5/11/49	1.13	678	T3N/R7E-12M1	9/ 7/49	0.28	157
T3N/R6E-17R1	7/ 8/49	1.41	672	T3N/R7E-13N1	5/17/49	0.28	222
T3N/R6E-17R1	9/ 7/49	0.84	614	T3N/R7E-13N1	7/ 6/49	0.84	222
T3N/R6E-18B1	5/22/50	1.29	558	T3N/R7E-18P3	5/17/50	0.65	303
T3N/R6E-18J2	5/18/50	0.96	499	T3N/R7E-18P3	8/ 9/50	0.62	314
T3N/R6E-18J2	8/ 9/50	0.79	272	T3N/R7E-20J1	5/19/50	0.53	272
T3N/R6E-18K1	5/11/49	1.69	678	T3N/R7E-21M2	5/17/49	0.56	286
T3N/R6E-18K1	7/ 8/49	1.97	672	T3N/R7E-21M2	7/ 7/49	1.13	350
T3N/R6E-18K1	9/ 7/49	1.41	572	T3N/R7E-25B1	5/17/49	0.28	222
T3N/R6E-20A1	5/11/49	2.25	964	T3N/R7E-25B1	7/ 6/49	0.56	214
T3N/R6E-20A1	7/ 8/49	2.53	928	T3N/R7E-29M1	5/19/50	0.70	274
T3N/R6E-20E1	5/18/50	2.99	704	T3N/R7E-33E1	5/17/49	0.56	279
T3N/R6E-20H1	5/22/50	1.89	584	T3N/R7E-33E1	9/ 2/49	0.28	269
T3N/R6E-20H1	8/ 9/50	1.86	743	T2N/R6E-9C1	5/18/49	1.14	428
T3N/R6E-20P1	5/11/49	1.13	500	T2N/R6E-9C1	9/ 6/49	0.56	329
T3N/R6E-20P1	7/ 8/49	1.13	472	T2N/R6E-10H1	5/18/49	0.56	300
T3N/R6E-20P1	9/ 2/49	0.84	457	T2N/R6E-13B1	5/18/49	0.56	428
T3N/R6E-21C2	5/22/50	2.99	820	T2N/R6E-13B1	7/20/49	0.56	364
T3N/R6E-21C2	8/ 9/50	2.56	786	T2N/R6E-21L1	5/20/49	0.84	472
T3N/R6E-21Q1	5/18/50	1.01	533	T2N/R6E-21L1	7/20/49	0.28	307
T3N/R6E-22H2	5/18/50	0.17	454	T2N/R6E-21L1	9/ 6/49	0.56	300
T3N/R6E-23D1	5/12/49	0.56	414	T2N/R6E-26K2	5/25/49	0.28	343
T3N/R6E-23D2	7/11/49	1.69	600	T2N/R6E-26K2	7/12/49	0.56	329
T3N/R6E-24B1	5/15/50	0.17	230	T2N/R6E-26K2	9/ 6/49	1.69	400
T3N/R6E-24D1	5/15/50	0.90	390	T2N/R6E-26P2	5/20/49	1.69	1,050
T3N/R6E-24K2	5/15/50	2.25	855	T2N/R6E-34B2	5/19/49	1.41	357
T3N/R6E-24M1	5/15/50	0.31	232	T2N/R6E-34B2	7/12/49	1.69	450
T3N/R6E-24M1	8/ 9/50	0.84	343	T2N/R6E-34B2	9/12/49	0.28	186
T3N/R6E-24N1	5/18/50	1.32	576	T2N/R7E-2B2	5/26/49	0.56	400
T3N/R6E-25B1	5/12/49	0.84	457	T2N/R7E-2B2	7/13/49	0.84	407
T3N/R6E-25B1	7/ 8/49	0.84	414	T2N/R7E-5H1	5/23/49	0.28	300
T3N/R6E-25B1	5/12/50	0.70	421	T2N/R7E-5H1	7/12/49	0.56	301
T3N/R6E-25B1	8/ 9/50	1.84	386	T2N/R7E-5H1	9/ 1/49	0.56	301
T3N/R6E-25F3	5/15/50	0.73	345	T2N/R7E-8L3	5/25/49	0.28	404
T3N/R6E-27C1	5/19/50	0.56	494	T2N/R7E-8L3	7/20/49	0.28	364
T3N/R6E-29D1	5/22/50	2.45	834	T2N/R7E-10F1	5/26/49	0.56	472
T3N/R6E-29D1	8/ 9/50	2.25	843	T2N/R7E-10F1	7/13/49	0.28	336
T3N/R6E-30F1	5/11/49	0.84	307	T2N/R7E-17A2	5/24/49	0.84	543
T3N/R6E-30F1	7/ 8/49	0.84	336	T2N/R7E-17A2	7/13/49	0.84	557
T3N/R6E-30F1	9/ 1/49	0.28	300	T2N/R7E-17A2	9/12/49	0.84	472
T3N/R6E-30R1	5/11/49	0.28	203	T2N/R7E-17B1	5/24/49	0.56	486
T3N/R6E-30R1	9/ 1/49	0.28	200	T2N/R7E-17B1	7/13/49	0.84	478
T3N/R6E-30R1	5/23/50	0.17	222	T2N/R7E-26E1	5/23/49	0.56	286

RECORDS OF PARTIAL MINERAL ANALYSES OF GROUND WATER IN SAN JOAQUIN AREA—Continued

(Water samples collected by the Division of Water Resources)

Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10^6 at 25° C.	Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10^6 at 25° C.
T2N/R7E-26E1	7/13/49	0.56	286	T1N/R6E-11P1	5/20/49	7.32	1,070
T2N/R7E-26H4	5/18/49	0.56	428	T1N/R6E-11P1	7/12/49	7.60	872
T2N/R7E-26H4	7/13/49	0.56	357	T1N/R6E-11P1	9/12/49	8.73	943
T2N/R7E-27F1	7/13/49	0.28	279	T1N/R6E-12B4	5/20/49	3.09	686
T2N/R7E-27F2	5/18/49	0.56	300	T1N/R6E-12B4	7/12/49	4.51	686
T2N/R7E-27F2	9/7/49	0.28	271	T1N/R6E-12L3	5/20/49	0.56	257
T2N/R7E-28K1	5/18/49	0.84	428	T1N/R6E-12L3	7/12/49	0.84	243
T2N/R7E-28K1	7/13/49	0.84	422	T1N/R6E-12L3	9/2/49	0.56	243
T2N/R7E-31A1	5/20/49	0.28	243	T1N/R6E-12M3	7/13/49	1.69	507
T2N/R7E-31A1	7/13/49	0.28	229	T1N/R6E-12N3	5/24/49	1.41	486
T2N/R7E-33B1	5/18/49	0.56	428	T1N/R6E-13D1	5/24/49	1.41	486
T2N/R7E-34G1	5/18/49	0.28	243	T1N/R6E-13D1	7/11/49	1.69	422
T2N/R7E-34G1	7/11/49	0.28	229	T1N/R6E-14Q1	5/23/49	0.84	314
T2N/R7E-35N1	5/18/49	0.56	371	T1N/R6E-15E2	5/19/49	22.82	2,290
T2N/R7E-35N1	7/13/49	0.28	243	T1N/R6E-16A1	5/17/49	35.21	2,570
T2N/R7E-35N1	9/12/49	0.28	243	T1N/R6E-16H3	5/17/49	25.63	2,290
T2N/R7E-36D1	5/27/49	0.28	272	T1N/R6E-16H3	9/13/49	36.62	3,430
T2N/R7E-36D1	7/19/49	0.28	278	T1N/R6E-17D1	5/17/49	34.93	2,570
T2N/R7E-36D1	9/12/49	0.28	257	T1N/R6E-17D1	9/13/49	35.21	3,000
T2N/R8E-10C1	5/27/49	0.28	236	T1N/R6E-23R1	5/23/50	5.10	620
T2N/R8E-10C1	7/20/49	0.28	231	T1N/R6E-23R1	8/10/50	4.53	713
T2N/R8E-19B1	5/27/49	0.28	386	T1N/R6E-25H1	5/23/50	1.58	431
T2N/R8E-19B1	7/20/49	0.28	346	T1N/R6E-25H1	8/10/50	1.63	411
T2N/R8E-24A1	5/27/49	0.28	214	T1N/R6E-25N1	5/10/50	3.32	620
T2N/R8E-24A1	7/11/49	0.28	207	T1N/R6E-25N1	8/10/50	1.18	297
T2N/R8E-25P1	5/27/49	0.28	186	T1N/R6E-36M1	5/10/50	1.66	407
T2N/R8E-25P1	7/11/49	0.28	207	T1N/R6E-36R1	8/16/50	1.63	573
T2N/R8E-25P1	9/7/49	0.28	186	T1N/R7E-4P1	5/18/49	0.28	243
T2N/R8E-29M1	5/23/49	0.28	228	T1N/R7E-4P1	7/11/49	0.56	236
T2N/R8E-29M1	7/11/49	0.28	207	T1N/R7E-7H1	5/24/49	0.84	386
T2N/R8E-29M1	9/1/49	0.28	200	T1N/R7E-8F1	5/24/49	1.97	714
T2N/R9E-8A1	5/27/49	0.28	271	T1N/R7E-8H1	5/24/49	2.25	672
T2N/R9E-8A1	7/19/49	0.28	254	T1N/R7E-8H1	7/13/49	1.97	507
T2N/R9E-36R2	5/9/50	0.73	222	T1N/R7E-8M1	5/24/49	1.41	457
T2N/R9E-36R2	8/11/50	0.28	210	T1N/R7E-8M1	7/19/49	1.41	400
T1N/R6E-1P1	5/20/49	0.56	243	T1N/R7E-9D1	5/18/49	0.84	457
T1N/R6E-1P1	7/12/49	0.84	243	T1N/R7E-9D1	7/11/49	0.84	422
T1N/R6E-1P1	9/13/49	1.41	314	T1N/R7E-9D1	9/8/49	0.84	336
T1N/R6E-2L2	5/20/49	2.82	500	T1N/R7E-9E2	5/24/49	1.41	472
T1N/R6E-2L2	7/12/49	2.25	414	T1N/R7E-9E2	7/11/49	1.13	400
T1N/R6E-2L2	9/12/49	2.25	428	T1N/R7E-9E2	9/20/49	0.84	400
T1N/R6E-3B1	5/19/49	2.25	428	T1N/R7E-9N1	5/18/49	0.84	278
T1N/R6E-3B1	7/12/49	1.97	357	T1N/R7E-9N1	7/11/49	0.56	243
T1N/R6E-3B1	9/12/49	1.69	343	T1N/R7E-9N1	9/8/49	0.28	243
T1N/R6E-3M1	5/19/49	2.82	571	T1N/R7E-10E2	5/24/49	0.28	214
T1N/R6E-3M1	7/12/49	4.51	643	T1N/R7E-10E2	7/11/49	0.56	204
T1N/R6E-3M1	9/12/49	2.25	514	T1N/R7E-10E2	9/8/49	0.28	200
T1N/R6E-3M2	5/19/49	1.41	443	T1N/R7E-10G1	5/24/49	0.28	171
T1N/R6E-3M3	5/19/49	0.84	386	T1N/R7E-10G1	7/13/49	0.28	160
T1N/R6E-3M3	7/12/49	1.69	450	T1N/R7E-10G1	9/8/49	0.28	171
T1N/R6E-3M3	9/12/49	1.13	343	T1N/R7E-11M1	5/24/49	0.28	200
T1N/R6E-10J1	5/19/49	5.63	942	T1N/R7E-11M1	7/13/49	0.28	204
T1N/R6E-10J1	7/12/49	5.63	829	T1N/R7E-11M1	9/8/49	0.28	200
T1N/R6E-10J1	9/13/49	5.63	829	T1N/R7E-14M1	5/18/50	0.59	298
T1N/R6E-10Q1	5/19/49	21.12	2,280	T1N/R7E-14M1	8/15/50	0.45	297
T1N/R6E-10Q1	9/13/49	21.69	1,860	T1N/R7E-16P2	5/18/50	0.73	346
T1N/R6E-10Q2	5/19/49	12.96	1,570	T1N/R7E-18D1	5/24/49	1.97	528
T1N/R6E-10Q2	9/13/49	11.83	1,230	T1N/R7E-18D1	7/19/49	1.97	507
T1N/R6E-10Q3	5/19/49	6.20	943	T1N/R7E-18E1	5/18/49	1.41	372
T1N/R6E-10Q3	7/12/49	6.20	828	T1N/R7E-18E1	7/19/49	1.13	314
T1N/R6E-10Q4	9/13/49	6.76	856	T1N/R7E-19A1	5/23/49	1.41	414
T1N/R6E-10Q4	5/19/49	31.49	2,140	T1N/R7E-19A1	7/11/49	1.41	400
T1N/R6E-10Q4	9/13/49	33.80	3,150	T1N/R7E-19A1	9/12/49	0.84	428
T1N/R6E-10Q5	5/19/49	10.42	1,570	T1N/R7E-19D3	5/10/50	1.07	408
T1N/R6E-10Q5	9/13/49	25.92	2,430	T1N/R7E-19D3	8/10/50	1.13	380

RECORDS OF PARTIAL MINERAL ANALYSES OF GROUND WATER IN SAN JOAQUIN AREA—Continued

(Water samples collected by the Division of Water Resources)

Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10⁶ at 25° C.	Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10⁶ at 25° C.
T1N/R7E-19D1	5/23/50	0.68	340	T1N/R9E-8H1	5/ 9/50	0.59	223
T1N/R7E-20K1	5/10/50	1.01	370	T1N/R9E-8H1	8/11/50	0.42	270
T1N/R7E-20K1	8/16/50	1.18	365	T1N/R9E-13A1	5/ 9/50	0.59	250
T1N/R7E-20Q1	5/10/50	0.73	293	T1N/R9E-13A1	8/11/50	0.48	220
T1N/R7E-20Q1	8/10/50	0.79	292	T1N/R9E-16A2	5/ 9/50	0.59	223
T1N/R7E-21H1	5/18/50	0.73	324	T1N/R9E-16A2	8/11/50	0.42	180
T1N/R7E-21H1	8/10/50	0.90	324	T1N/R9E-18G1	5/27/49	0.28	164
T1N/R7E-21M2	5/18/50	1.63	458	T1N/R9E-18G1	7/19/49	0.56	169
T1N/R7E-21M2	8/10/50	1.44	411	T1N/R9E-18P1	5/24/50	0.31	214
T1N/R7E-23N1	5/18/50	0.96	374	T1N/R9E-23C1	5/ 9/50	0.45	204
T1N/R7E-23N1	8/15/50	1.01	384	T1N/R9E-23C1	8/16/50	0.48	191
T1N/R7E-28D1	5/10/50	0.87	352	T1N/R9E-26M1	5/ 9/50	0.31	183
T1N/R7E-28D1	8/10/50	0.90	350	T1N/R9E-26M1	8/11/50	0.42	186
T1N/R7E-28D2	5/10/50	0.87	309	T1N/R9E-30B2	5/24/50	0.34	213
T1N/R7E-28D2	8/10/50	0.51	233	T1N/R9E-30B2	8/15/50	0.34	198
T1N/R7E-30E1	5/10/50	0.73	293	T1N/R9E-32M1	4/27/50	0.28	201
T1N/R7E-30E1	8/10/50	0.45	273	T1N/R9E-32M1	8/11/50	0.37	202
T1N/R7E-33D1	5/10/50	0.45	272	T1N/R9E-32R1	4/27/50	0.45	197
T1N/R7E-35H1	5/18/50	0.59	365	T1N/R9E-32R1	8/11/50	0.59	210
T1N/R7E-35H1	8/10/50	1.13	457	T1N/R10E-22H1	8/ /50	0.28	210
T1N/R7E-36M1	5/12/50	0.87	400	T1S/R6E-6J2	5/10/50	7.94	1,170
T1N/R7E-36M1	8/11/50	0.90	399	T1S/R7E-2E1	5/10/50	2.06	403
T1N/R8E-6D1	5/27/49	0.56	214	T1S/R7E-3M1	8/16/50	1.29	403
T1N/R8E-6D1	7/11/49	0.28	186	T1S/R7E-3R1	5/17/50	0.68	308
T1N/R8E-6D1	9/12/49	0.28	200	T1S/R7E-3R1	8/10/50	0.62	284
T1N/R8E-10C1	5/25/49	0.28	157	T1S/R7E-5B1	5/12/50	1.38	308
T1N/R8E-10C1	7/11/49	0.28	163	T1S/R7E-6J2	8/16/50	7.46	1,130
T1N/R8E-10C1	9/ 8/49	0.28	157	T1S/R7E-6R1	5/17/50	7.91	1,106
T1N/R8E-14J1	5/27/49	0.56	200	T1S/R7E-8M1	5/10/50	2.06	847
T1N/R8E-14J1	7/11/49	0.28	207	T1S/R7E-10D1	5/10/50	0.59	274
T1N/R8E-17A1	5/27/49	0.56	303	T1S/R7E-10D1	8/16/50	0.65	272
T1N/R8E-17A1	7/22/49	0.56	246	T1S/R7E-14E1	5/17/50	0.59	269
T1N/R8E-17A1	9/20/49	0.28	243	T1S/R7E-24E1	5/17/50	0.87	585
T1N/R8E-17A1	5/24/50	0.45	284	T1S/R7E-24E1	8/10/50	1.01	617
T1N/R8E-17A1	8/14/50	0.51	272	T1S/R8E-3L1	5/12/50	0.31	234
T1N/R8E-19B1	5/18/50	0.39	247	T1S/R8E-3L1	8/15/50	0.39	228
T1N/R8E-19C1	5/18/50	0.45	265	T1S/R8E-4D1	5/18/50	0.08	227
T1N/R8E-22M1	5/24/50	0.22	262	T1S/R8E-4D1	8/ /50		248
T1N/R8E-22M1	8/14/50	0.34	246	T1S/R8E-4H1	5/12/50	0.45	234
T1N/R8E-23M1	5/16/50	0.34	238	T1S/R8E-4H1	8/15/50	0.34	281
T1N/R8E-25F1	5/24/50	0.25	219	T1S/R8E-4L1	5/18/50	0.45	248
T1N/R8E-25F1	8/15/50	0.28	199	T1S/R8E-4L1	8/15/50	0.39	259
T1N/R8E-26K2	5/16/50	0.28	234	T1S/R8E-4M1	5/18/50	0.25	219
T1N/R8E-26K2	8/16/50	0.42	265	T1S/R8E-4M1	8/15/50	0.34	224
T1N/R8E-26K3	5/16/50	0.31	196	T1S/R8E-5E1	5/12/50	0.65	285
T1N/R8E-26K3	8/14/50	0.42	183	T1S/R8E-5E1	8/11/50	0.56	255
T1N/R8E-26R1	5/24/50	0.45	217	T1S/R8E-5L1	5/16/50	0.93	346
T1N/R8E-29J1	5/12/50	0.45	219	T1S/R8E-5L1	8/10/50	0.79	352
T1N/R8E-29J1	8/14/50	0.37	227	T1S/R8E-5M1	5/16/50	0.56	263
T1N/R8E-29L1	5/12/50	0.87	337	T1S/R8E-5M1	8/10/50	0.39	220
T1N/R8E-29L1	8/15/50	0.87	348	T1S/R8E-5R1	5/16/50	0.56	342
T1N/R8E-30D1	5/23/50	0.59	296	T1S/R8E-5R1	8/10/50	0.62	354
T1N/R8E-30D1	8/14/50	0.51	285	T1S/R8E-6A1	5/12/50	0.59	271
T1N/R8E-32G1	5/16/50	1.01	361	T1S/R8E-6A1	8/11/50	0.62	279
T1N/R8E-32G1	8/14/50	1.01	348	T1S/R8E-8D1	5/16/50	1.01	286
T1N/R8E-33M1	5/16/50	0.31	228	T1S/R8E-8M1	5/16/50	0.70	345
T1N/R8E-33M1	8/14/50	0.42	225	T1S/R8E-8M1	8/10/50	0.62	333
T1N/R8E-34F1	5/16/50	0.31	231	T1S/R8E-9D1	5/18/50	0.62	238
T1N/R8E-34F1	8/16/50	0.93	447	T1S/R8E-9D1	8/15/50	0.51	232
T1N/R8E-34J1	5/16/50	0.17	194	T1S/R8E-10B1	5/18/50	0.31	215
T1N/R8E-34J1	8/14/50	0.31	214	T1S/R8E-10B1	8/15/50	0.51	278
T1N/R8E-35B1	5/24/50	0.59	228	T1S/R8E-12P1	5/12/50	0.45	209
T1N/R8E-35B1	8/14/50	0.39	198	T1S/R8E-12P1	8/15/50	0.56	278
T1N/R8E-36F1	5/24/50	1.86	190	T1S/R8E-13D2	5/ 9/50	0.73	250
T1N/R8E-36F1	5/15/50	0.37	185	T1S/R8E-15D1	5/23/50	0.45	202

RECORDS OF PARTIAL MINERAL ANALYSES OF GROUND WATER IN SAN JOAQUIN AREA—Continued

(Woter somples collected by the Division of Water Resources)

Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10⁶ at 25° C.	Well number	Date sampled	Chlorides, in equivalents per million	Conductance, Ec × 10⁶ at 25° C.
T1S/R8E-15D1	8/15/50	0.45	206	T1S/R8E-32E1	5/17/50	1.21	433
T1S/R8E-16B1	5/18/50	0.45	250	T1S/R9E-5M1	5/ 9/50	0.53	215
T1S/R8E-22H2	5/23/50	0.31	181	T1S/R9E-5M1	8/11/50	0.42	236
T1S/R8E-22H2	8/15/50	0.45	199	T1S/R9E-5R1	5/ 9/50	0.53	218
T1S/R8E-24A1	5/23/50	0.65	290	T1S/R9E-5R1	8/15/50	0.37	238
T1S/R8E-24A1	8/15/50	0.39	195	T1S/R9E-8H1	5/ 9/50	0.59	237
T1S/R8E-24N1	5/23/50	0.53	275	T1S/R9E-8H1	8/11/50	0.42	198
T1S/R8E-24N1	8/11/50	0.45	261	T1S/R9E-9R1	5/ 9/50	0.51	220
T1S/R8E-24R1	5/23/50	0.56	285	T1S/R9E-9R1	8/15/50	0.59	313
T1S/R8E-24R1	8/11/50	0.42	290	T1S/R9E-17N1	5/ 9/50	0.42	277
T1S/R8E-29H1	5/ 2/50	0.34	318	T1S/R9E-18R1	5/12/50	0.42	294
T1S/R8E-30B1	5/17/50	1.01	384	T1S/R9E-18R1	8/ /50	----------	264
T1S/R8E-30B1	8/10/50	1.01	359				
T1S/R8E-30R1	5/17/50	1.58	488				
T1S/R8E-30R1	8/10/50	1.52	599				

APPENDIX G

APPLICATIONS TO APPROPRIATE WATER IN AND ADJACENT TO SAN JOAQUIN AREA

(Filed With Division of Water Resources, Department of Public Works, Under Provisions of Water Code, State of California, November 1, 1953)

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TABLE 1

APPLICATIONS TO APPROPRIATE WATER FROM DRY CREEK AND TRIBUTARIES, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion		Storage, in acre-feet	Purpose	Status
					in second-feet	in gallons per day			
2575	10/5/21	L. M. Tregaskies	Mule Creek	SE¼ NE¼ Sec. 12, T.6N, R.9E			15	Irrigation, domestic, and stockwatering	License
5647	7/30/27	State of California	Dry Creek	SE¼ Sec. 7, T.7N, R.11E	50		5,000	Irrigation and domestic	Incomplete
			Sutter Creek	SE¼ Sec. 22, T.7N, R.12E	50		5,000		
12041	8/13/47	Leslie and Ida Dietrick	Unnamed spring	NE¼ SE¼ Sec. 36, T.7N, R.11E		3,000		Domestic	License
12342	2/20/48	Amador County	Dry Creek	SE¼ NE¼ Sec. 1, T.6N, R.9E	60		30,000	Irrigation and domestic	Incomplete
			Sutter Creek	NW¼ SE¼ Sec. 15, T.6N, R.10E	60		10,000		
			Jackson Creek	SW¼ SE¼ Sec. 2, T.5N, R.10E	60		6,000		
12427	3/22/48	State of California, Youth Authority	Sutter Creek	SE¼ SE¼ Sec. 1, T.6N, R.10E	10			Power	Permit
12428	3/22/48	State of California, Youth Authority	Sutter Creek	SE¼ SE¼ Sec. 1, T.6N, R.10E	4.5		817	Irrigation, domestic and recreational	Permit
12434	3/24/48	State of California, Youth Authority	Sutter Creek	NW¼ NE¼ Sec. 26, T.6N, R.9E	2.5			Irrigation	Permit
12843	12/2/48	North San Joaquin Water Conservation District	Dry Creek	SE¼ Sec. 33, T.5N, R.10E	500		10,000	Irrigation and domestic	Incomplete
				East line of Sec. 26 to west line of Sec. 32, T.5N, R.7E	100		15,000		
12895	1/10/49	Gladys I. Franklin	Mule Creek	SE¼ NE¼ Sec. 12, T.6N, R.9E			30	Irrigation	Permit
13036	4/21/49	Amador County	Jackson Creek	SE¼ Sec. 2, T.5N, R.10E	50		5,000	Irrigation, domestic and stockwatering	Incomplete
13039	4/21/49	Amador County	Dry Creek	NE¼ Sec. 1, T.6N, R.9E	200		15,000	Irrigation, domestic and stockwatering	Incomplete
13041	4/21/49	Amador County	Sutter Creek	Between SW¼ Sec. 23, T.7N, R.12E and W½ Sec. 22, T.6N, R.9E	100			Irrigation, domestic and stockwatering	Incomplete
				W½ Sec. 21, T.6N, R.10E			50,000		
				SW¼ Sec. 23, T.7N, R.12E			50,000		
13380	10/3/49	J. M. Thomas	Mule Creek	SW¼ NE¼ Sec. 8, T.6N, R.10E			15	Irrigation and stockwatering	Permit
15217	3/3/53	Emma M. Goffinet	Unnamed stream	SW¼ NE¼ Sec. 16, T.6N, R.10E			70	Irrigation	Pending
			Jackass Creek	SE¼ NW¼ Sec. 16, T.6N, R.10E			127		

TABLE 2

APPLICATIONS TO APPROPRIATE WATER FROM MOKELUMNE RIVER AND TRIBUTARIES, EXCLUDING DRY CREEK, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion: in second-feet	Diversion: Storage, in per day	Storage, in acre-feet	Purpose	Status
2100	11/30/20	Pacific Gas and Electric Company	North Fork of Mokelumne River	NW¼ SE¼ Sec. 33, T.8N, R.16E	350		60,000	Power	License
2534	9/ 3/21	Pacific Gas and Electric Company	North Fork of Mokelumne River	NW¼ SE¼ Sec. 33, T.8N, R.16E	125		85,000	Power	License
2548	9/14/21	Pacific Gas and Electric Company	Cold (Cole) Creek Bear Creek Beaver Creek	NW¼ NW¼ Sec. 5, T.7N, R.16E NW¼ NE¼ Sec. 2, T.7N, R.15E SW¼ NE¼ Sec. 3, T.7N, R.15E	20 305 20			Power	License
2751	2/ 9/22	Pacific Gas and Electric Company	North Fork of Mokelumne River	NW¼ SE¼ Sec. 33, T.8N, R.16E			9,412	Power	Permit
2882	6/16/22	Mattie Mehrten	Mokelumne River	NE¼ NW¼ Sec. 14, T.4N, R.8E	0.37			Agricultural	License
2948	7/28/22	Reclamation District No. 756	South Fork of Mokelumne River and two other points	Movable point T.3N, R.4E	71.56			Irrigation	License
2996	8/21/22	Pacific Gas and Electric Company	North Fork of Mokelumne River	SW¼ NE¼ Sec. 33, T.7N, R.13E	225			Power	License
3161	11/27/22	Ren Featherston	Mokelumne River	NW¼ NW¼ Sec. 15, T.4N, R.8E SE¼ SW¼ Sec. 16, T.4N, R.8E	1.9			Irrigation	License
3213	11/ 5/23	Margaret Clements, et al.	Mokelumne River	SE¼ NE¼ Sec. 16, T.4N, R.8E NW¼ SE¼ Sec. 16, T.4N, R.8E	5.6			Irrigation	License
3270	2/26/23	H. Shafer, et al.	Mokelumne River	SW¼ NE¼ Sec. 6, T.4N, R.10E	0.45			Irrigation, domestic and stockwatering	Permit
3349	4/11/23	Raymond A. Kissel	Mokelumne River	NE¼ SW¼ Sec. 6, T.4N, R.9E	0.12			Irrigation	License
3453	5/29/23	Estate of A. Galluzzi	Mokelumne River	NE¼ NW¼ Sec. 15, T.4N, R.8E	0.16			Irrigation	License
3613	8/25/23	Brack Reclamation District No. 2033	Mokelumne River and other slough Sycamore Slough and Dredger Cut	T.3N, R.4E Movable point	49.38			Agricultural	License
3617	8/29/23	Caterina Costa, et al.	Mokelumne River	SE¼ SE¼ Sec. 17, T.4N, R.8E	0.32			Irrigation	License
3811	1/26/24	Verne W. Hoffman	Mokelumne River	NW¼ NW¼ Sec. 34, T.4N, R.7E	0.4			Irrigation	License
3821	2/ 2/24	W. E. and R. Melhoff	Mokelumne River	SE¼ SE¼ Sec. 28, T.4N, R.7E	1.0			Irrigation	License
3830	2/ 7/24	F. and E. Kirschenman	Mokelumne River	NW¼ SE¼ Sec. 34, T.4N, R.7E	2.12			Irrigation	License
3887	3/ 5/24	Pierce and Alice Plasse	Unnamed spring	NE¼ NE¼ Sec. 18, T.9N, R.17E NW¼ SW¼ Sec. 17, T.9N, R.17E	0.012 18.75			Domestic Agricultural	License License
3914	3/21/24	McCormack-Williamson Company	Mokelumne River Snodgrass Slough Dredger Cut	SW¼ NW¼ Sec. 31, T.5N, R.5E 4 other points on other sources	19.8			Agricultural	License
3990	5/15/24	R. N. Blossom, et al.	Mokelumne River	NE¼ SW¼ Sec. 34, T.5N, R.5E	12.0			Agricultural	Permit
3996	5/20/24	C. L. Allen	Mokelumne River	NW¼ NE¼ Sec. 30, T.4N, R.8E	0.81			Irrigation	License
4215	9/16/24	E. M. Locke, et al.	Mokelumne River	NW¼ NW¼ Sec. 30, T.4N, R.8E SE¼ SE¼ Sec. 24, T.4N, R.7E	2.08			Irrigation	License
4228	9/22/24	East Bay Municipal Utility District	Mokelumne River	E½ of NW¼ and W½ of NE¼ of Sec. 26, T.5N, R.10E	310		217,000	Municipal	Permit
4398	12/23/24	Henry G. Ostermann, et al.	Mokelumne River	NE¼ NE¼ Sec. 9, T.4N, R.9E	1.05			Irrigation	License
4400	12/23/24	E. A. Barbera	Sycamore Slough	SE¼ NE¼ Sec. 2, T.3N, R.4E SW¼ NE¼ Sec. 1, T.3N, R.4E NW¼ NW¼ Sec. 1, T.3N, R.4E	4.96			Irrigation	License
4405	12/29/24	J. W. Steely	Mokelumne River	SW¼ SE¼ Sec. 10, T.4N, R.8E	0.44			Irrigation	Permit
4474	2/20/25	Henry G. Ostermann, et al.	Mokelumne River	NE¼ NE¼ Sec. 9, T.4N, R.9E	1.05			Irrigation	License
4768	9/11/25	East Bay Municipal Utility District	Mokelumne River	NW¼ SW¼ Sec. 26, T.5N, R.10E	37.50		198,965	Power	License
4894	1/21/26	Frank Amaio, et al.	Beaver Slough	SE¼ SW¼ Sec. 8, T.4N, R.5E	1.89			Agricultural	License
5002	4/21/26	East Bay Municipal Utility District	Mokelumne River	SE¼ NE¼ Sec. 16, T.5N, R.11E	750		25,000	Power	Permit
5092	7/10/26	E. Gianelli, et al.	Beaver Slough and movable point between limits of South Fork of Mokelumne River	NW¼ NW¼ Sec. 17, T.4N, R.5E SE¼ SE¼ Sec. 12, T.4N, R.4E	13.52			Irrigation	License
5128	7/26/26	East Bay Municipal Utility District	Mokelumne River	NW¼ SW¼ Sec. 26, T.5N, R.10E NE¼ SW¼ Sec. 26, T.5N, R.10E	375		50,000	Power	Permit
5161	8/19/26	Pacific Gas and Electric Company	North Fork of Mokelumne River	NW¼ SE¼ Sec. 33, T.8N, R.16E			9,412	Power	Permit
5240	10/22/26	Pacific Gas and Electric Company	North Fork of Mokelumne River	NW¼ SE¼ Sec. 33, T.8N, R.16E	125		85,000	Power	License
5647	7/30/27	State of California, Department of Finance	North Fork of Mokelumne River Mokelumne River below Electra Dry Creek Sutter Creek	NW¼ Sec. 13, T.7N, R.14E Sec. 32, T.6N, R.12E Sec. 7, T.7N, R.11E Sec. 22, T.7N, R.12E	400 600 50 50		100,000 5,000 5,000	Irrigation and domestic	Incomplete

TABLE 2—Continued

APPLICATIONS TO APPROPRIATE WATER FROM MOKELUMNE RIVER AND TRIBUTARIES, EXCLUDING DRY CREEK, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
5648	7/30/27	State of California, Department of Finance	Forest Creek	Sec. 34, T.7N, R.14E	25			Irrigation and domestic	Incomplete
			Middle Fork of Mokelumne River	Sec. 12, T.6N, R.13E			40,000		
			Middle Fork of Mokelumne River	Sec. 8, T.6N, R.13E	140				
			South Fork of Mokelumne River	Sec. 23, T.6N, R.13E			40,000		
			South Fork of Mokelumne River	Sec. 2, T.5N, R.14E	25				
			South Fork of Mokelumne River	Sec. 16, T.6N, R.13E	230				
			Mokelumne River	Sec. 18, T.5N, R.11E	300				
5807	1/20/28	Woodbridge Irrigation District	Mokelumne River	NE¼ SE¼ Sec. 34, T.4N, R.6E	300			Irrigation and domestic	Permit
5957	6/25/28	P. F. Sievers	Mokelumne River	NE¼ NW¼ Sec. 14, T.4N, R.8E	0.37			Irrigation and domestic	License
6032	8/29/28	Pacific Gas and Electric Company	Bear River Cold (Cole) Creek	SE¼ Sec. 18, T.8N, R.16E NW¼ SE¼ Sec. 28, T.8N, R.16E	200		50,000	Power	Permit
6145	12/26/28	Thornton Farms	Mokelumne River	NE¼ SE¼ Sec. 11, T.4N, R.5E NW¼ SW¼ Sec. 2, T.4N, R.5E	8.75			Irrigation	License
6262	4/20/29	Pacific Gas and Electric Company	North Fork of Mokelumne River	NW¼ SE¼ Sec. 33, T.8N, R.16E	550			Power	License
6430	9/6/29	W. S. Orvis	State Canal	NE¼ NW¼ Sec. 15, T.8N, R.16E NE¼ NW¼ Sec. 15, T.4N, R.5E NE¼ NE¼ Sec. 16, T.4N, R.5E	9.1			Agricultural	License
6576	2/26/30	E. T. Bamert	Mokelumne River	NW¼ SW¼ Sec. 4, T.4N, R.9E	1.0			Irrigation	License
6737	7/19/30	Pacific Gas and Electric Company	Tiger Creek	SW¼ NE¼ Sec. 8, T.7N, R.14E	75.0			Power	License
6738	7/19/30	Pacific Gas and Electric Company	West Panther Creek East Panther Creek	NE¼ NE¼ Sec. 2, T.7N, R.14E SW¼ NW¼ Sec. 1, T.7N, R.14E	33.8 47.1			Power	License
7149	12/16/31	State Division of Highways	Unnamed spring	NW¼ SE¼ Sec. 16, T.9N, R.16E		3,000		Domestic and fire protection	License
7150	12/16/31	State Division of Highways	Tragedy Spring	NW¼ SW¼ Sec. 7, T.9N, R.17E		1,000		Recreation	License
8406	8/3/35	S. Dinelli, et al	Mokelumne River	SW¼ SE¼ Sec. 19, T.5N, R.5E	0.31			Irrigation	License
8871	1/8/37	Nelson Davis	Mokelumne River	NE¼ NW¼ Sec. 34, T.4N, R.7E	0.4			Irrigation	License
9796	12/23/39	J. M. Prentice, et al	Mokelumne River	NE¼ SE¼ Sec. 26, T.4N, R.7E	0.5			Irrigation	License
9828	2/16/40	E. F. Bernasconi	Dogtown Gulch	SE¼ NW¼ Sec. 12, T.6N, R.13E		3,000		Domestic	License
10068	11/20/40	E. H. Nevin, et al	Dredger Cut	NE¼ SE¼ Sec. 17, T.5N, R.5E	9.65			Irrigation and stockwatering	License
10240	7/17/41	Woodbridge Water Users Association	Mokelumne River	NE¼ SE¼ Sec. 34, T.4N, R.6E	300			Irrigation, domestic, and stockwatering	Permit
10296	10/14/41	United States Stanislaus National Forest	Tryon Meadow Creek	NE¼ NW¼ Sec. 32, T.8N, R.20E		3,000		Domestic, stockwatering, and fire protection	License
10357	1/8/42	C. R. Brown	Mokelumne River	NE¼ SE¼ Sec. 1, T.4N, R.9E	0.048			Irrigation and domestic	License
10531	9/2/42	Thornton Farms	Mokelumne River	NE¼ NE¼ Sec. 3, T.4N, R.5E.	1.85			Irrigation	License
10553	11/4/42	V. W. Hoffman	Mokelumne River	NW¼ NW¼ Sec. 34, T.4N, R.7E	0.35			Irrigation	License
10741	12/24/43	J. Deardorff, et al	Humbug Gulch	NW¼ SW¼ Sec. 21, T.6N, R.13E NE¼ SE¼ Sec. 20			20	Irrigation	Permit
10875	9/6/44	Ray J. Barber	Unnamed stream	SW¼ NE¼ Sec. 25, T.7N, R.13E	1.0			Domestic, power, mining, and irrigation	Permit
10950	1/9/45	J. E. Willard, et al	Campo Flores Gulch	NW¼ NE¼ Sec. 12, T.6N, R.13E		300		Domestic	License
11526	8/22/46	E. H. and H. C. Nevin	Unnamed dredger cut	NE¼ SE¼ Sec. 17, T.5N, R.5E	2.38			Irrigation and stockwatering	License
11562	9/23/46	P. Sinnock	5 springs and unnamed stream	NE¼ NW¼ Sec. 8, T.6N, R.13E NW¼ NE¼ Sec. 8, T.6N, R.13E	0.11			Irrigation	Permit
11637	11/29/46	S. L. Wilcox and Tessie Wilcox	Stone (Bloom) Lake	NW¼ NE¼ Sec. 24, T.6N, R.4E	0.32			Irrigation	Permit
11644	12/3/46	C. L. Bloom, et al	Stone (Bloom) Lake	NW¼ NE¼ Sec. 24, T.6N, R.4E	0.62			Irrigation and stockwatering	License
11652	12/10/46	E. E. Jensen	3 unnamed springs	NE¼ NE¼ Sec. 12, T.6N, R.13E		16,000		Domestic	Permit
11792	3/24/47	Calaveras County Water District	Bear Creek	SW¼ NE¼ Sec. 1, T.6N, R.13E SW¼ NW¼ Sec. 29, T.7N, R.14E	10.0		1,550	Irrigation, domestic, industrial, municipal, mining, and recreational	Pending
			North Fork of Middle Fork of Mokelumne River	SE¼ NW¼ Sec. 34, T.7N, R.14E			1,300		
			Middle Fork of Mokelumne River	SE¼ SW¼ Sec. 12, T.6N, R.13E SW¼ SW¼ Sec. 9, T.6N, R.14E	50.0		3,600		
			South Fork of Mokelumne River	SW¼ SW¼ Sec. 16, T.6N, R.13E NE¼ SE¼ Sec. 1, T.5N, R.14E	50.0		1,850		
			South Fork of Mokelumne River	SE¼ NE¼ Sec. 23, T.6N, R.13E			17,000		

TABLE 2—Continued

APPLICATIONS TO APPROPRIATE WATER FROM MOKELUMNE RIVER AND TRIBUTARIES, EXCLUDING DRY CREEK, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion		Storage, in acre-feet	Purpose	Status
					in second-feet	in gallons per day			
11810	4/ 3/47	S. and J. Klein	Beaver Slough	SW¼ SE¼ Sec. 8, T.4N, R.5E	3.04			Irrigation	License
11977	7/ 9/47	P. L. and V. A. Stabell	Mokelumne River	SW¼ SW¼ Sec. 16, T.4N, R.8E	1.2			Irrigation	Permit
11992	7/16/47	United States El Dorado National Forest	Peddler Hill Spring	NE¼ SE¼ Sec. 1, T. 8N, R.15E	0.004			Domestic and recreational	Permit
12241	1/13/48	R.F. and C. S. Fiddymont	Beaver Slough	SE¼ SE¼ Sec. 10, T.4N, R.5E	4.1			Irrigation	Permit
12539	6/ 9/48	J. V. Lucas	Mokelumne River	NE¼ NE¼ Sec. 12, T.4N, R.8E; NW¼ NW¼ Sec. 7, T.4N, R.9E	1.30			Irrigation	Permit
12567	6/25/48	Alice Oldfield	Little Garden Spring	SE¼ NE¼ Sec. 27, T.7N, R.13E	0.025			Domestic	Permit
12648	8/12/48	Woodbridge Irrigation District	Beaver Slough	SW¼ SW¼ Sec. 11, T.4N, R.5E	30			Irrigation	Permit
12842	12/ 2/48	North San Joaquin Water Conservation District	Mokelumne River	Lot 3, Sec. 7, T.4N, R.9E			50,000	Irrigation, domestic, municipal, recreational and industrial	Pending
				SW¼ SE¼ Sec. 11, T.4N, R.8E	250				
				SW¼ SW¼ Sec. 24, T.4N, R. 7E	250				
12843	12/ 2/48	North San Joaquin Water Conservation District	Mokelumne River	SE¼ Sec. 5, T.4N, R.9E	500		78,000	Irrigation and domestic	Incomplete
				SW¼ Sec. 5, T.4N, R.10E	500		25,000		
				SW¼ Sec. 4, T.4N, R.10E	500		25,000		
				SE¼ Sec. 33, T.5N, R.10E	500		40,000		
			Bear Creek	Movable between west line of Sec. 23, T.4N, R.8E and west line of Sec. 31, T.3N, R.7E	100		15,000		
			Paddy Creek	Sec. 27, T.3N, R.7E	100		5,000		
12897	1/11/49	Clarence L. and Laurel C. Bloom	Stone (Bloom) Lake	NW¼ NE¼ Sec. 24, T.6N, R.4E	2.2			Irrigation	Permit
12953	2/24/49	Calaveras County Water District	South Fork of Mokelumne River	NE¼ NE¼ Sec. 33, T.6N, R.14E			3,700	Irrigation and domestic	Pending
13034	4/21/49	County of Amador	East Panther Creek	NW¼ Sec. 35, T.8N, R.15E	20		4,000	Irrigation, domestic and stockwatering	Incomplete
			Panther Creek	NE¼ Sec. 25, T.8N, R.14E	20		3,500		
			Tiger Creek	E½ Sec. 5, T.7N, R.14E	25		5,000		
			Mill Creek	N½ Sec. 6, T.7N, R.14E	10		2,000		
			West Fork of Tiger Creek	W½ Sec. 5, T.7N, R.14E	10		1,000		
			Antelope Creek	SE¼ Sec. 2, T.7N, R.13E	15		3,000		
13156	6/16/49	East Bay Municipal Utility District	Mokelumne River	SE¼ SE¼ Sec. 6, T.4N, R.9E			212,000	Municipal	Pending
				NW¼ SW¼ Sec. 26, T.5N, R.10E			17,000		
				SW¼ NE¼ Sec. 16, T.5N, R.11E			44,000		
			South Fork of Mokelumne River	NW¼ NE¼ Sec. 23, T.6N, R.13E			80,000		
13249	7/21/49	County of Calaveras	South Fork of Mokelumne River	NE¼ NE¼ Sec. 3, T.5N, R.14E	100		80,000	Irrigation and domestic	Incomplete
13265	7/28/49	Calaveras County Water District	Blue Creek	NW¼ NE¼ Sec. 25, T.7N, R.15E	10			Municipal	Pending
			Bear Creek	SW¼ NW¼ Sec. 29, T.7N, R.14E			1,550		
			North Fork of Middle Fork of Mokelumne River	SE¼ NW¼ Sec. 34, T.7N, R.14E			1,300		
13477	11/22/49	H. A. and M. S. Higdon	Unnamed gulch	NE¼ SE¼ Sec. 5, T.6N, R.13E			40	Irrigation and stockwatering	Permit
13652	3/27/50	United States El Dorado National Forest	Mud Lake Spring	SE¼ SW¼ Sec. 19, T.9N, R.17E		100		Domestic and stockwatering	Permit
13853	7/18/50	North San Joaquin Water Conservation District	Beaver Slough	SE¼ SE¼ Sec. 10, T.4N, R.5E	50			Irrigation and domestic	Incomplete
13854	7/18/50	North San Joaquin Water Conservation District	Sycamore Slough	SE¼ SE¼ Sec. 33, T.4N, R.5E	200			Irrigation and domestic	Incomplete
14020	10/25/50	J. Deardorff, et al	Humbug Gulch	NE¼ SE¼ Sec. 20, T.6N, R.13E			50	Irrigation	Permit
14100	12/12/50	C. G. Best	Reclamation District No. 1002 Drainage Canal	NW¼ NW¼ Sec. 17, T.5N, R.5E	0.31			Irrigation	Permit
14642	1/21/52	County of Alpine	North Fork of Mokelumne River	Sec. 13, T.8N, R.18E	10		50,000	Domestic, irrigation and recreational	Incomplete
14643	1/21/52	County of Alpine	North Fork of Mokelumne River	Sec. 13, T.8N, R.18E	10		50,000	Power and recreational	Incomplete
14644	1/21/52	County of Alpine	North Fork of Mokelumne River	Sec. 6, T.8N, R.18E	10		100,000	Domestic, irrigation and recreational	Incomplete
14645	1/21/52	County of Alpine	North Fork of Mokelumne River	Sec. 6, T.8N, R.18E	10		100,000	Power and recreational	Incomplete
14724	3/21/52	I. James	Little and Big Sandy Gulch	NE¼ NW¼ Sec. 16, T.6N, R.13E			70	Irrigation and stockwatering	Permit
14857	6/13/52	B. Doscher	North Fork of Mokelumne River	SE¼ SE¼ Sec. 27, T.7N, R.13E	0.056			Mining	Permit
14883	6/30/52	United States Stanislaus National Forest	Lower Highland Lake	NW¼ SE¼ Sec. 32, T.8N, R.20E			140	Recreational	Permit

TABLE 2—Continued

APPLICATIONS TO APPROPRIATE WATER FROM MOKELUMNE RIVER AND TRIBUTARIES, EXCLUDING DRY CREEK, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
14906	7/11/52	R. H. De Vinny	Mokelumne River	SW¼ SW¼ Sec. 5, T.4N, R.10E	0.33			Mining and domestic	Permit
15135	12/23/52	G. E. Everett	Beaver Slough	SW¼ SE¼ Sec. 9, T.4N, R.5E	3			Irrigation and stockwatering	Permit
15136	12/23/52	G. E. Everett	Beaver Slough	SE¼ SE¼ Sec. 8, T.4N, R.5E	2			Irrigation and stockwatering	Permit
15201	2/16/53	East Bay Municipal Utility District	Mokelumne River	SE¼ SE¼ Sec. 6, T.4N, R.9E			212,000	Power and domestic	Pending
				NW¼ SW¼ Sec. 26, T.5N, R.10E			17,000		
				SW¼ NE¼ Sec. 16, T.5N, R.11E			44,000		
			South Fork of Mokelumne River	NW¼ NE¼ Sec. 23, T.6N, R.13E			80,000		
15202	2/18/53	C. Green	Mokelumne River	NE¼ NE¼ Sec. 5, T.3N, R.7E	1.6			Irrigation and stockwatering	Permit

TABLE 3

APPLICATIONS TO APPROPRIATE WATER FROM BEAR CREEK AND TRIBUTARIES, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
12341	2/19/48	E. L. Maupin	Bear Creek	NW¼ SW¼ Sec. 23, T.3N, R.7E	1.65			Irrigation and stockwatering	Permit
12426	3/22/48	Robert E. Eietderich, et al.	Paddy Creek	NE¼ NE¼ Sec. 23, T.3N, R.7E	0.75			Irrigation and stockwatering	Permit
12444	3/29/48	Dewey Murdock	Bear Creek	SE¼ NW¼ Sec. 23, T.3N, R.7E	0.44			Irrigation	Permit
12445	3/29/48	Melvin O. Hieb	Bear Creek	SW¼ NW¼ Sec. 23, T.3N, R.7E	0.71			Irrigation	Permit
12446	3/29/48	Le Roy L. Hieb	Bear Creek	SW¼ NW¼ Sec. 23, T.3N, R.7E	0.59			Irrigation	Permit
12447	3/29/48	C. A. Eddlemon, et al.	Bear Creek	SE¼ NW¼ Sec. 23, T.3N, R.7E	1.28			Irrigation	Permit
12448	3/29/48	C. A. Eddlemon, et al.	Bear Creek	NW¼ SW¼ Sec. 23, T.3N, R.7E	0.88			Irrigation	Permit
12449	3/29/48	Charles J. Faber	Bear Creek	SW¼ SE¼ Sec. 14, T.3N, R.7E	2.88			Irrigation	Permit
12450	3/29/48	Donald H. Hieb	Bear Creek	SW¼ NW¼ Sec. 23, T.3N, R.7E	0.86			Irrigation	Permit
12451	3/29/48	Ludwig F. Hieb	Bear Creek	SW¼ NW¼ Sec. 23, T.3N, R.7E	0.98			Irrigation	Permit
12660	8/19/48	Christian Ulrich, et al.	Unnamed stream, tributary to Bear Creek	NW¼ NW¼ Sec. 25, T.3N, R.7E	0.031			Domestic, irrigation and stockwatering	Permit
12842	12/ 2/48	North San Joaquin Water Conservation District	Paddy Creek	Sec. 27, T.3N, R.7E	100		5,000	Municipal	Pending
			Bear Creek	Sec. 31, T.3N, R.7E	100		15,000	Municipal	Pending
12843	12/ 2/48	North San Joaquin Water Conservation District	Paddy Creek	Sec. 27, T.3N, R.7E	100		5,000	Irrigation and domestic	Pending
			Bear Creek	Sec. 31, T.3N, R.7E	100		15,000		
14592	12/ 4/51	Winfield S. Montgomery Jr.	Bear Creek	NE NW¼ Sec. 32, T.4N, R.8E	8		2	Irrigation	Permit
14621	1/18/52	F. A. Engel, et al.	Bear Creek	NW¼ NW¼ Sec. 23, T.4N, R.8E	1.54		4.3	Irrigation and stockwatering	Permit
14971	8/13/52	M. L. & M. Nies, H. R. & E. I. Nickel	Bear Creek	SE¼ SE¼ Sec. 11, T.3N, R.7E	0.25			Irrigation	Permit
15102	12/ 2/52	G. Davis	Unnamed stream, tributary to Bear Creek	NE¼ SW¼ Sec. 7, T.3N, R.8E	0.40			Irrigation	Pending
15132	12/22/52	D. H. & M. O. Hieb	Pixley Creek	NE¼ SE¼ Sec. 22, T.3N, R.7E	0.86			Irrigation	Permit
15256	3/30/53	I. C. & R. L. Mettler	Paddy Creek	SW¼ SW¼ Sec. 13, T.3N, R.7E	0.5			Irrigation	Pending
15362	6/ 1/53	E. Ferrario	Unnamed creek, tributary to Bear Creek	SE¼ NW¼ Sec. 19, T.4N, R.10E	0.5			Irrigation	Pending
				SW¼ NW¼ Sec. 20, T.4N, R.10E	1.5		750		

TABLE 4

APPLICATIONS TO APPROPRIATE WATER FROM CALAVERAS RIVER AND TRIBUTARIES, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
2380	6/ 6/21	L. F. Grimsley Inc., Albert A. Anderson and W. D. Winton	Calaveras River	SW¼ NW¼ Sec. 4, T.2N, R. 9E	2.56			Irrigation	License
2381	6/ 6/21	George A. Ditz et al	Calaveras River	NW¼ SE¼ Sec. 5, T.2N, R.9E	1.44			Irrigation	License
2839	5/ 4/22	Raymond T. McGurk Sr.	Calaveras River	(Movable) S½ Sec. 33, T.3N, R.9E	1.00			Irrigation	License
3335	3/20/23	R. C. Sweet, Jr.	South Fork of Esperanza Creek	S½ NW¼ Sec. 15, T.5N, R.13E	0.056			Irrigation and domestic	License
3640	9/17/23	V. R. Smith	Unnamed Canyon	NE¼ NW¼ Sec. 4, T.3N, R.10E			31.5	Irrigation	License
3725	11/22/23	Frieda Sender	El Dorado Creek	SW¼ SW¼ Sec. 34, T.5N, R.13E	0.021			Agricultural and domestic	License
3776	12/29/23	Vernon L. Vignolo et al	Calaveras River	NW¼ NW¼ Sec. 4, T.2N, R.9E	1.25			Irrigation	License
4742	8/19/25	Calaveras Cement Co.	Calaveritas Creek	NW¼ NE¼ Sec. 32, T.4N, R.12E	1.0			Industrial	License
4778	9/18/25	Mrs. W. H. Roe	Murray Creek	NW¼ NW¼ Sec. 34, T.5N, R.13E	0.016			Irrigation and domestic	License
5648	7/30/27	State of California	Calaveras River	SW¼ Sec. 31, T.4N, R.11E	800		100,000	Irrigation and domestic	Incomplete
6522	1/ 3/30	Stockton and East San Joaquin Water Conservation District	Calaveras River	NE¼ SW¼ Sec. 5, T.2N, R.9E	13.75		11,500	Irrigation and domestic	License
6612	3/28/30	George A. Ditz et al	Calaveras River	NW¼ SE¼ Sec. 5, T.2N, R.9E	1.44			Irrigation	Permit
6623	4/ 5/30	L. F. Grimsley Inc., et al	Calaveras River	SW¼ NW¼ Sec. 4, T.2N, R.9E	2.56			Irrigation	Permit
6624	4/ 5/30	Raymond T. McGurk, Sr.	Calaveras River	S½ Sec. 33, T.3N, R.9E	0.81			Irrigation	License
7090	10/13/31	Lydia Kolher	Thompson Spring	SE¼ NW¼ Sec. 6, T.4N, R.13E	0.002			Irrigation and domestic	License
7124	11/13/31	F. C. Stolte, Jr. and C. L. Stolte	Mormon Slough	NW¼ Sec. 7, T.2N, R.9E	3.9			Irrigation	License
7549	5/ 4/33	J. B. Ryburn	Potter Creek Tributary to Mormon Slough	SE¼ SW¼ Sec. 18, T.2N, R.9E	0.75			Irrigation and domestic	License
8659	5/ 8/36	George Schmauder	South Fork of Calaveras River	SW¼ NE¼ Sec. 30, T.4N, R.12E	0.19			Mining	License
9342	7/ 6/38	Calaveras Cement Co.	South Fork of Calaveras River	NW¼ NE¼ Sec. 32, T.4N, R.12E			90	Industrial	Permit
9647	6/29/39	V. R. Smith	Unnamed stream	NE¼ NW¼ Sec. 4, T.3N, R.10E	29			Irrigation and domestic	Permit
10088	12/19/40	P. H. Cox	Potter creek, tributary to Mormon Slough	N½ NW¼ Sec. 24, T.2N, R.8E	3.0			Irrigation	Permit
10808	5/ 2/44	Stockton Golf and Country Club	Calaveras River	NW¼ NE¼ Sec. 6, T.1N, R.6E	1.15			Irrigation	License
10867	8/25/44	State Division of Beaches and Parks	Unnamed spring	SW¼ NW¼ Sec. 15, T.5N, R.15E	0.016			Domestic and fire protection	License
11550	9/12/46	W. R. and John A. Huberty	North Fork of Calaveras River	SE¼ NW¼ Sec. 6, T.4N, R.12E	0.75			Irrigation	Permit
				SW¼ NW¼ Sec. 6, T.4N, R.12E			20		
11788	3/20/47	G. M. Robertson and Wife	O'Neil Creek	NW¼ NW¼ Sec. 33, T.5N, R.14E	0.125			Irrigation and domestic	Permit
11792	3/24/47	Calaveras County Water District	Calaveras River	SW¼ NW¼ Sec. 31, T.4N, R.11E	50.0		100,000	Irrigation, mining, municipal, industrial, recreation and domestic	Pending
			North Fork of Calaveras River	NE¼ SW¼ Sec. 33, T.6N, R.13E			2,650		
				SE¼ SE¼ Sec. 35, T.6N, R.13E	10.0		60,000		
			Esperanza Creek	SE¼ SW¼ Sec. 11, T.5N, R.13E	5.0		22,320		
			Jesus Maria Creek	SW¼ SW¼ Sec. 25, T.5N, R.13E	5.0		14,000		
			O'Neil Creek	NE¼ SE¼ Sec. 28, T.5N, R.14E	10.0		17,000		
			San Antonio Creek	NW¼ SE¼ Sec. 9, T.4N, R.14E	10.0		18,000		
11815	4/ 7/47	Calaveras Cement Company	Esperanza Creek	Lot 7, Sec. 6, T.5N, R.13E; Lot 7, Sec. 7, T.5N, R.13E	2.5		100	Industrial	Permit
12373	3/ 2/48	State of California, Youth Authority	San Antonio Creek	SE¼ SW¼ Sec. 9, T.4N, R.14E			4	Irrigation and domestic	Permit
12668	8/25/48	Stockton and East San Joaquin Water Conservation District	Calaveras River	SW¼ SW¼ Sec. 31, T.4N, R.11E			76,000	Irrigation and domestic	Pending
12722	9/30/48	Calaveras Cement Company	South Fork of Calaveras River	NW¼ NE¼ Sec. 32, T.4N, R.12E	2.0			Industrial	Permit
12751	10/19/48	J. E. & L. M. Grawell	Unnamed stream, tributary to Mormon Slough	NW¼ NW¼ Sec. 2, T.1N, R.8E	0.25			Irrigation and stockwatering	License
12839	12/ 1/48	Stockton and East San Joaquin Water Conservation District	Calaveras River	NE¼ NE¼ Sec. 36, T.3N, R.9E			200,000	Irrigation and domestic	Pending
13245	7/21/49	County of Calaveras	Calaveras River	SW¼ Sec. 31, T.4N, R.11E	50		100,000	Irrigation, domestic and stockwatering	Incomplete
			North Fork of Calaveras River	SW¼ Sec. 33, T.6N, R.13E	10		5.000		
				E½ Sec. 35, T.6N, R.13E			3,000		
			Esperanza Creek	SW¼ Sec. 11, T.5N, R.13E	5		6,500		
			Jesus Maria Creek	SE¼ Sec. 24, T.5N, R.13E	5		9,000		
			O'Neil Creek	NE¼ Sec. 27, T.5N, R.14E	10		7,000		
			San Antonio Creek	SE¼ Sec. 26, T.5N, R.14E	10		25,000		

TABLE 4—Continued

APPLICATIONS TO APPROPRIATE WATER FROM CALAVERAS RIVER AND TRIBUTARIES, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian		Diversion		Storage, in acre-feet	Purpose	Status
						in second-feet	in gallons per day			
13423	10/27/49	Stockton and East San Joaquin Water Conservation District	Calaveras River	SW¼ NW¼	Proj. 26, T.2N, R.6E	175			Irrigation and domestic	Incomplete
13424	10/27/49	Stockton and East San Joaquin Water Conservation District	Calaveras River	SW¼ NW¼	Proj. 26, T.2N, R.6E	175			Municipal	Incomplete
13817	6/27/50	N. H. & L. H. Christensen	Steele Creek, tributary to Calaveras River	NW¼ SW¼ SE¼ NE¼	Sec. 7, T.3N, R.12E Sec. 12, T.3N, R.11E	 1.5		50 50	Irrigation and stockwatering	Permit
13916	8/24/50	R. J. Romaggi	Unnamed stream, tributary to Cowell Creek, San Antonio Creek	SE¼ SW¼ SE¼ SE¼	Sec. 31, T.5N, R.15E Sec. 30, T.5N, R.15E			10 15	Irrigation and recreation	Permit
13923	8/25/50	Tanner Brothers	Cowell Creek, tributary to San Antonio Creek	NE¼ NE¼	Sec. 1, T.4N, R.14E	1.0		124	Irrigation	Permit
14095	12/ 6/50	W. W. Elzig	Unnamed stream, tributary to Salamander Creek, Jesus Maria Creek	NW¼ NW¼	Sec. 31, T.5N, R.13E	0.125			Irrigation	Permit
14250	4/12/51	Calaveras County Water District	San Domingo Creek	SW¼ SE¼	Sec. 36, T.4N, R.13E	25.0		12,700	Irrigation	Pending
14251	4/12/51	Calaveras County Water District	San Domingo Creek	SW¼ SE¼	Sec. 36, T.4N, R.13E	3.0		2,200	Municipal	Pending
14295	5/ 8/51	J. J. Snyder	Unnamed stream, tributary to Cosgrove Creek	SW¼ NE¼	Sec. 7, T.4N, R.11E	2.5		68	Irrigation	Permit
14598	12/10/51	D. B. Vincent	Jesus Maria Creek	NE¼ NW¼	Sec. 14, T.5N, R.14E	0.084			Irrigation, domestic and stockwatering	Permit
14786	4/30/52	C. B. Swinborne	Unnamed spring	SW¼ SE¼	Sec. 10, T.4N, R.11E	0.12			Irrigation, domestic and stockwatering	Permit
14976	8/18/52	L. B. Darby	Unnamed spring, tributary to San Domingo Creek	NW¼ SE¼	Sec. 24, T.4N, R.14E	0.08			Irrigation and domestic	Permit
14992	8/25/52	R. V. Garamendi	What Cheer Gulch Chili Gulch	NE¼ SW¼ SW¼ NE¼	Sec. 24, T.5N, R.11E Sec. 24, T.5N, R.11E	1.0		5 40	Irrigation, domestic and stockwatering	Permit
15142	1/ 2/53	B. E. Case	Mormon Slough	NE¼ SW¼	Sec. 23, T.2N, R.8E	2.4			Irrigation	Pending
15159	1/20/53	E. Faust	South Fork of Willow Creek	SE¼ SW¼ SW¼ SE¼ NE¼ NE¼	Sec. 9, T.4N, R.13E Sec. 9, T.4N, R.13E Sec. 17, T.4N, R.13E	0.76		 3 10	Irrigation, domestic and stockwatering	Permit
15172	1/27/53	L. Domenghini	Unnamed gulch, tributary to El Dorado Creek	NE¼ NW¼	Sec. 4, T.4N, R.13E			18	Irrigation	Permit
15209	2/25/53	H. L. Lombardi	Calaveras River	SE¼ SE¼	Sec. 35, T.4N, R.10E	3.0			Irrigation, domestic and stockwatering	Pending
15255	3/26/53	F. J. & J. E. Lewis	Unnamed creek	SW¼ NE¼	Sec. 1, T.5N, R.13E			200	Irrigation	Incomplete

TABLE 5

APPLICATIONS TO APPROPRIATE WATER FROM DUCK CREEK, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion		Storage, in acre-feet	Purpose	Status
					in second-feet	in gallons per day			
12004	7/23/47	A. J. Batteate et al.	Duck Creek	SW¼ SW¼ Sec. 17, T.1N, R.9E	1.0			Irrigation and stockwatering	License
12752	10/19/48	Virgil Groves	Unnamed stream, tributary to Duck Creek	NE¼ NE¼ Sec. 16, T.1N, R.9E	0.75			Irrigation and stockwatering	Permit
			Duck Creek	NE¼ SW¼ Sec. 16, T.1N, R.9E	2.25				
12976	3/14/49	Wesley F. Fowler	Duck Creek	SE¼ NE¼ Sec. 16, T.1N, R.8E	3.0			Irrigation	Permit
			Unnamed stream, tributary to Duck Creek	NW¼ SW¼ Sec. 10, T.1N, R.8E					
13814	6/26/50	Leslie Hunt	Duck Creek	SE¼ NW¼ Sec. 13, T.1N, R.8E	9.0			Irrigation	Permit
15079	11/7/52	Arthur T. Chute	Duck Creek	NW¼ NW¼ Sec. 12, T.1N, R.7E	3.0			Irrigation and stockwatering	Permit
15288	4/13/53	W. L. & A. F. Ripley	Duck Creek	SE¼ NE¼ Sec. 15, T.1N, R.8E	3.0			Irrigation	Pending
15360	5/28/53	P. S. & E. M. Sanguinetti	Duck Creek	NW¼ SE¼ Sec. 10, T.1N, R.7E	3.0			Irrigation	Pending
15361	5/28/53	A. M. S. Minahen	Duck Creek	NW¼ SW¼ Sec. 11, T.1N, R.7E	3.0			Irrigation	Pending
15545	9/18/53	James E. Soares	Unnamed slough, tributary to Duck Creek	NW¼ NE¼ Sec. 8, T.1N, R.8E	1.5			Irrigation	Pending

TABLE 6

APPLICATIONS TO APPROPRIATE WATER FROM LITTLEJOHNS CREEK, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion		Storage, in acre-feet	Purpose	Status
					in second-feet	in gallons per day			
405	7/18/16	Renaldo Jeffrey et al.	Little Johns Creek	Sec. 35, T.4N, R.10E	0.5			Irrigation	License
				Sec. 36, T.4N, R.10E					
6539	1/20/30	Louis Imfeld	Drain ditch	NE¼ SW¼ Sec. 17, T.1S, R.9E	0.11			Irrigation	License
9451	11/14/38	Jumbo Consolidated Mining Co.	Clover Creek	SW¼ NW¼ Sec. 30, T.2N, R.12E	3.0		82	Mining	Permit
9714	8/29/30	John Zwald	Little Johns Creek	SE¼ SE¼ Sec. 34, T.1N, R.10E	0.25			Irrigation and domestic	License
10864	8/16/44	J. F. Goodwin Co.	Little Johns Creek	NE¼ SE¼ Sec. 35, T.1N, R.7E	3.0			Irrigation and stockwatering	License
11364	4/8/46	J. F. Goodwin Co.	Little Johns Creek	NW¼ SE¼ Sec. 32, T.1N, R.8E	3.0			Irrigation and stockwatering	Permit
11366	4/9/46	J. George Sanguinetti	Little Johns Creek	SW¼ NW¼ Sec. 26, T.1N, R.9E	0.5			Irrigation	Permit
				SW¼ NW¼ Sec. 26, T.1N, R.9E					
12249	1/19/48	Elmer S. & Ollie M. Ladd	South Fork Little Johns Creek	NE¼ SW¼ Sec. 2, T.1S, R.7E	3.0			Irrigation	Permit
12536	6/7/48	Calaveras County Water District	Clover Creek	NW¼ NE¼ Sec. 31, T.2N, R.12E			1,230	Irrigation and domestic	Pending
			Little Johns Creek	SW¼ NW¼ Sec. 5, T.1N, R.12E			1,840		
				SW¼ SE¼ Sec. 5, T.1N, R.12E			1,620		
				SW¼ NE¼ Sec. 9, T.1N, R.12E			640		
				SE¼ SW¼ Sec. 9, T.1N, R.12E			1,330		
13107	5/20/49	Edward A. Schultz	Little Johns Creek	NE¼ NE¼ Sec. 3, T.1S, R.7E	3.0			Irrigation	Permit
				SW¼ SW¼ Sec. 3, T.1S, R.7E					
13132	6/2/49	Wilbur L. & Wilbur B. Salmon	Little Johns Creek	SE¼ NE¼ Sec. 6, T.1S, R.7E	5.5			Irrigation and stockwatering	Permit
				SE¼ NW¼ Sec. 6, T.1S, R.7E					
13244	7/21/49	County of Calaveras	Clover Creek	NW¼ NE¼ Sec. 31, T.2N, R.12E			2,000	Irrigation and domestic	Incomplete
			Little Johns Creek	SW¼ NW¼ Sec. 5, T.1N, R.12E			10,000		
				SE¼ SE¼ Sec. 5, T.1N, R.12E			1,000		
				NW¼ NW¼ Sec. 9, T.1N, R.12E			2,000		
				SW¼ SW¼ Sec. 9, T.1N, R.12E			8,000		
13333	3/6/49	Department of Finance, State of California	Little Johns Creek	W½ Sec. 35, T.1N, R.10E	150		31,100	Municipal	Incomplete
13334	9/6/49	Department of Finance, State of California	Little Johns Creek	W¼ Sec. 35, T.1N, R.10E	150		31,100	Irrigation, domestic and flood control	Incomplete
13335	9/6/49	Department of Finance, State of California	Hoods Creek	SE¼ Sec. 21, T.1N, R.10E	65		14,100	Irrigation, domestic and flood control	Incomplete
				SW¼ Sec. 22, T.1N, R.10E					
13336	9/6/49	Department of Finance, State of California	Hoods Creek	SE¼ Sec. 21, T.1N, R.10E	65		14,100	Municipal	Incomplete
				SW¼ Sec. 22, T.1N, R.10E					
13337	9/6/49	Department of Finance, State of California	Rock Creek	NE¼ Sec. 17, T.1N, R.10E	100		9,000	Irrigation, domestic and flood control	Incomplete
13338	9/6/49	Department of Finance, State of California	Rock Creek	NE¼ Sec. 17, T.1N, R.10E	100		9,000	Municipal	Incomplete
13897	8/15/50	Carolyn E. Flower	Little Johns Creek	SW¼ NW¼ Sec. 5, T.1N, R.12E			790	Irrigation	Permit

TABLE 7

APPLICATIONS TO APPROPRIATE WATER FROM UNNAMED STREAMS AND TURNER SLOUGH, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
10673	7/14/43	Benedix Bros.	Unnamed stream	NE¼ NE¼ Sec. 9, T.1S, R.8E	3			Irrigation	Permit
10811	5/ 8/44	Bessie L. Shipley	Unnamed stream	SE¼ SE¼ Sec. 5, T.1S, R.9E	1.9			Irrigation	License
11238	12/15/45	Benedix Bros.	Unnamed stream	NE¼ NE¼ Sec. 9, T.1S, R.8E	2.55			Irrigation	Permit
12346	2/21/48	Lawrence Edith Brickey	Unnamed stream	SE¼ SE¼ Sec. 4, T.1S, R.8E	3			Irrigation and stock-watering	Permit
12626	7/30/48	Elmer Norgard Estate	Unnamed slough	NW¼ NE¼ Sec. 3, T.1S, R.8E	0.9			Irrigation and domestic	Permit
13165	6/21/49	F. H. & D. I. Middleton	Turner Slough	SW¼ NE¼ Sec. 1, T.1S, R.8E	2.75			Irrigation and stock-watering	License

TABLE 8

APPLICATIONS TO APPROPRIATE WATER FROM LONE TREE CREEK, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
2358	5/26/21	Jessie Carlson Gaar	Lone Tree Creek	SE¼ NE¼ Sec. 8, T.1S, R.7E	0.56			Irrigation	License
6264	4/22/29	Mrs. Geraldine Day & E. D. Stevens	Lone Tree Creek	SE¼ NE¼ Sec. 24, T.1S, R.7E	2.0			Irrigation	License
6397	8/ 7/29	Amelia W. McFall	Lone Tree Creek	NE¼ NE¼ Sec. 14, T.1S, R.7E SE¼ SW¼ Sec. 13, T.1S, R.7E	1.13			Irrigation	License
6748	7/24/30	Dr. F. J. O'Donnell	Lone Tree Creek	SE¼ NE¼ Sec. 26, T.1S, R.8E	2.0			Irrigation	License
8413	8/ 6/35	Maude Jones Eastman	Lone Tree Creek	SE¼ SE¼ Sec. 21, T.1S, R.8E	1.0			Irrigation	License
9201	12/ 8/37	Castle & Castle	Lone Tree Creek	SW¼ SW¼ Sec. 10, T.1S, R.7E	0.31			Irrigation	License
9519	3/ 8/39	Arnaudo Bros.	Lone Tree Creek	SE¼ SW¼ Sec. 13, T.1S, R.7E	0.7			Irrigation and stock-watering	License
11104	7/12/45	Albert J. Due	Lone Tree Creek	SE¼ NE¼ Sec. 19, T.1S, R.8E	0.08			Irrigation and stock-watering	License
12717	9/27/48	Lucky McFall	Lone Tree Creek	SE¼ NW¼ Sec. 19, T.1S, R.8E	0.625			Irrigation	Permit
15272	4/ 2/53	Maude Jones Eastman	Lone Tree Creek	SE¼ SE¼ Sec. 21, T.1S, R.8E	2.5			Irrigation	Permit

TABLE 9

APPLICATIONS TO APPROPRIATE WATER FROM FRENCH CAMP SLOUGH AND LITTLEJOHNS CREEK, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
4568	5/ 5/25	Cardyn Mc D. Weston	French Camp Slough	SE¼ SW¼ Sec. 21, T.1N, R.6E SW¼ SE¼ Sec. 22, T.1N, R.6E SE¼ SW¼ Sec. 22, T.1N, R.6E	4.93			Irrigation	License
5366	2/25/27	Milton G. Boege	French Camp Slough	NE¼ SE¼ Sec. 13, T.1N, R.6E SW¼ NW¼ Sec. 36, T.1N, R.6E	0.31			Irrigation	License
8821	10/30/36	Lucien Bascou	Little Johns Creek	SW¼ NW¼ Sec. 36, T.1N, R.6E	0.52			Irrigation	License
11095	7/ 2/45	John Crescini	French Camp Slough	SE¼ NE¼ Sec. 6, T.1S, R.7E	0.96			Irrigation	License
14516	10/ 9/51	J. E. & A. J. Anderson	Little Johns Creek	NE¼ SW¼ Sec. 36, T.1N, R.6E	5.55			Irrigation and stock-watering	Permit

TABLE 10

APPLICATIONS TO APPROPRIATE WATER FROM STANISLAUS RIVER AND TRIBUTARIES, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
77A	8/ 4/15	Pacific Gas and Electric Company	Highland Creek	NW¼ NE¼ Sec. 4, T.6N, R.18E			6,144	Power	Permit
1081	9/20/18	Oakdale and South San Joaquin Irrigation Districts	Stanislaus River	NW¼ SE¼ Sec. 11, T.1N, R.13E			96,195	Irrigation	License
1339	6/30/19	Pacific Gas and Electric Company	South Fork of Stanislaus River	SW¼ NW¼ Sec. 30, T.4N, R.18E	56.5			Power	License
1628	1/15/20	D. F. Koetitz	Stanislaus River	NE¼ SW¼ Sec. 2, T.3S, R.7E NW¼ SE¼ Sec. 2, T.3S, R.7E	0.69			Irrigation	License
2087	11/19/20	Lorenzo Zerillo	Stanislaus River	NE¼ NW¼ Sec. 26, T.2S, R.9E	0.15			Irrigation	License
2460	7/29/21	Pacific Gas and Electric Company	Stanislaus River	NW¼ SE¼ Sec. 11, T.1N, R.13E	1,500	132,450		Power	License
2524	8/29/21	South San Joaquin Irrigation District	Stanislaus River	SE¼ NE¼ Sec. 10, T.1S, R.12E		36,000		Irrigation	License
3091	10/19/22	Oakdale and South San Joaquin Irrigation Districts	Stanislaus River	NW¼ SE¼ Sec. 11, T.1N, R.13E		10,754		Irrigation	License
3395	5/ 2/23	G. J. Wagers	Big Meadows Creek	SE¼ NE¼ Sec. 32, T.7N, R.17E		650		Domestic	License
3516	7/ 9/23	D. F. Koetitz	Stanislaus River	NE¼ SW¼ Sec. 2, T.3S, R.7E	2.47			Irrigation	License
3602	8/20/23	Garnet T. Barron	Unnamed stream	NW¼ NW¼ Sec. 35, T.6N, R.20E		650		Domestic	License
3912	3/20/24	United States—Stanislaus National Forest	Gooseberry Spring	SE¼ SW¼ Sec. 14, T.4N, R.18E		50,000		Domestic	License
4895	1/26/26	Wade H. Coffill	Unnamed spring	NE¼ SE¼ Sec. 25, T.6N, R.19E		6,500		Recreation, domestic, and fire protection	License
5250	10/30/26	Helen S. Company	Unnamed spring	SE¼ NE¼ Sec. 17, T.3N, R.14E		400		Domestic	License
5414	4/11/27	Pacific Gas and Electric Company	Highland Creek	NE¼ NE¼ Sec. 9, T.6N, R.18E			4,656	Power	Permit
5648	7/30/27	State of California, Department of Finance, and Oakdale and South San Joaquin Irrigation Districts	Highland Creek North Fork of Stanislaus River Middle Fork of Stanislaus River Stanislaus River	NE¼ Sec. 9, T.6N, R.18E Sec. 2, T.4N, R.15E NW¼ Sec. 23, T.6N, R.16E NE¼ Sec. 14, T.4N, R.17E Sec. 11, T.1N, R.13E	 975 600		65,000 30,000 60,000	Irrigation and domestic	Incomplete
5649	7/30/27	State of California, Department of Finance	South Fork of Stanislaus River Sullivan Creek	SW¼ Sec. 24, T.3N, R.16E SW¼ Sec. 9, T.4N, R.19E SW¼ Sec. 15, T.4N, R.18E NE¼ Sec. 28, T.2N, R.15E	 50		17,000 15,000 27,000 13,000	Irrigation and domestic	Incomplete
6129	12/ 4/28	Pacific Gas and Electric Company	South Fork of Stanislaus River	SE¼ SW¼ Sec. 24, T.3N, R.16E			3,919	Power	License
6130	12/ 4/28	Pacific Gas and Electric Company	South Fork of Stanislaus River	SE¼ SW¼ Sec. 24, T.3N, R.16E			5,360	Irrigation and domestic	License
6764	8/11/30	State of California, Division of Highways	Unnamed spring	SE¼ NW¼ Sec. 32, T.7N, R.17E		6,500		Domestic and fire protection	License
6963	5/19/31	Leonard E. Ecklund and Gladys M. Ecklund	Stanislaus River	SE¼ NE¼ Sec. 3, T.3S, R.7E	8.94			Irrigation	Permit
6971	6/ 2/31	State of California, Division of Highways	Unnamed spring	NW¼ NW¼ Sec. 35, T.6N, R.20E		9,000		Irrigation, domestic and fire protection	License
7025	8/ 3/31	State of California, Division of Highways	Stoddard Spring	SW¼ NW¼ Sec. 10, T.3N, R.17E		1,000		Recreational	License
7166	1/ 5/32	State of California	Cottage Spring	SW¼ NE¼ Sec. 28, T.6N, R.16E		1,000		Recreational	License
7397	10/ 3/32	State of California, Division of Highways	Unnamed spring	SE¼ SE¼ Sec. 25, T.8N, R.18E		1,100		Recreational	License
8892	2/ 3/37	Oakdale Irrigation District	Stanislaus River	NE¼ NE¼ Sec. 18, T.2S, R.10E	4.54			Irrigation and domestic	
8919	3/13/37	R. H. Dynan	Unnamed spring, tributary to Lake Alpine	SE¼ SE¼ Sec. 8, T.7N, R.18E		360		Domestic	License
9217	12/30/37	R. H. Dynan	Unnamed spring	SE¼ SE¼ Sec. 8, T.7N, R.18E		360		Domestic	License
9620	6/15/39	Mitchell Terzick	Eagle Creek	NE¼ NE¼ Sec. 36, T.6N, R.19E	2.0			Power	Permit
9666	7/17/39	Oakdale Irrigation District	Stanislaus River	SW¼ SW¼ Sec. 9, T.2S, R.10E	1.68			Irrigation and domestic	License
9834	2/21/40	N. E. Cannon	Stanislaus River	SE¼ NE¼ Sec. 3, T.3S, R.7E	3.89			Irrigation and domestic	License
9851	3/14/40	R. H. Dynan	Unnamed spring	NW¼ SE¼ Sec. 8, T.7N, R.18E		1,200		Domestic	License
10122	2/19/41	Pacific Gas and Electric Company	Middle Fork of Stanislaus River	NE¼ SE¼ Sec. 24, T.4N, R.16E	160			Power	License
10168	3/25/41	Tamarack Cabin Owners Association	Two unnamed springs	NW¼ SE¼ Sec. 22, T.7N, R.17E		13,000		Domestic and fire protection	License
10384	2/ 6/42	United States—Stanislaus National Forest	Cow Creek	SE¼ NW¼ Sec. 34, T.5N, R.18E		14,000		Domestic, recreational, and fire protection	Permit
10386	2/ 6/42	United States—Stanislaus National Forest	Leland Creek	SW¼ SW¼ Sec. 34, T.5N, R.18E		8,000		Domestic, recreational, and fire protection	Permit

TABLE 10—Continued

APPLICATIONS TO APPROPRIATE WATER FROM STANISLAUS RIVER AND TRIBUTARIES, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
10437	4/25/42	United States—Stanislaus National Forest	Bee Creek	NW¼ SE¼ Sec. 4, T.7N, R.18E		1,400		Domestic, recreational, and fire protection	Permit
10466	5/25/42	A. Girardi	Stanislaus River	NW¼ NW¼ Sec. 28, T.2S, R.8E	3.0			Irrigation	Permit
10490	7/ 8/42	United States—Stanislaus National Forest	Unnamed spring	NW¼ NW¼ Sec. 35, T.6N, R.20E		2,600		Domestic and fire protection	License
10491	7/ 8/42	United States—Stanislaus National Forest	Unnamed stream	SW¼ NE¼ Sec. 25, T.6N, R.19E		2,600		Domestic, recreational, and fire protection	License
10492	7/ 9/42	United States—Stanislaus National Forest	Unnamed stream	SW¼ NE¼ Sec. 25, T.6N, R.19E		1,950		Domestic, recreational, and fire protection	License
10556	11/12/42	United States—Stanislaus National Forest	Bumble Bee Creek	SW¼ SW¼ Sec. 3, T.4N, R.18E		6,250		Domestic, recreational, and fire protection	Permit
10557	11/12/42	United States—Stanislaus National Forest	Cascade Creek	NE¼ NW¼ Sec. 23, T.5N, R.18E		2,600		Domestic, recreational, and fire protection	License
10575	12/28/42	United States—Stanislaus National Forest	Unnamed stream	SW¼ SE¼ Sec. 27, T.6N, R.20E		1,600		Domestic, recreational, and fire protection	License
10576	12/28/42	United States—Stanislaus National Forest	Unnamed stream	SW¼ SE¼ Sec. 27, T.6N, R.20E		2,000		Domestic, recreational, and fire protection	Permit
10584	1/ 2/43	United States—Stanislaus National Forest	Unnamed stream	NW¼ NE¼ Sec. 25, T.6N, R.19E		4,500		Domestic and fire protection	License
10585	1/ 2/43	United States—Stanislaus National Forest	Unnamed stream	NW¼ NE¼ Sec. 25, T.6N, R.19E		1,300		Domestic, stockwatering, and fire protection	License
10710	9/11/43	B. V. Bonora	Stanislaus River	NE¼ NE¼ Sec. 23, T.2S, R.8E	3.0			Irrigation	License
10872	8/30/44	Oakdale and South San Joaquin Irrigation Districts	Stanislaus River	Lot 5 Sec. 1, T.1S, R.12E			80,000	Irrigation	Permit
10978	2/10/48	Oakdale and South San Joaquin Irrigation Districts	Stanislaus River	NW¼ SE¼ Sec. 11, T.1S, R.13E			25,000	Irrigation	Permit
11105	7/13/45	Oakdale and South San Joaquin Irrigation Districts	Middle Fork of Stanislaus River	SW¼ NE¼ Sec. 14, T.4N, R.17E			110,000	Irrigation	Permit
11648	12/ 6/46	Sydney W. Reynolds	Bucks Slough	SW¼ SE¼ Sec. 20, T.2S, R.8E	0.36			Irrigation	License
11661	12/16/46	D. P. Pagani	Eagle Creek	SE¼ SW¼ Sec. 5, T.3N, R.16E SE¼ NW¼ Sec. 8, T.3N, R.16E	0.5			Irrigation and stockwatering	Permit
11741	2/21/47	Henry J. Schwatken	Stanislaus River	SW¼ NW¼ Sec. 36, T.1S, R.11E	1.0			Irrigation	Permit
11792	3/24/47	Calaveras County Water District	North Fork of Stanislaus River	SE¼ NW¼ Sec. 23, T.6N, R.16E SE¼ NE¼ Sec. 4, T.6N, R.17E			31,500 47,000	Irrigation, domestic, industrial, municipal, mining and recreational	Pending
12199	12/17/47	United States—Stanislaus National Forest	Unnamed spring	NW¼ SW¼ Sec. 20, T.4N, R.18E		1,100		Domestic	License
12200	12/17/47	United States—Stanislaus National Forest	Unnamed springs	SW¼ NW¼ Sec. 20, T.4N, R.18E		7,200		Domestic and fire protection	License
12257	1/23/48	Tuolumne County Water District No. 2	South Fork of Stanislaus River Herring Creek	SE¼ SW¼ Sec. 24, T.3N, R.16E NE¼ SW¼ Sec. 9, T.4N, R.19E SE¼ NW¼ Sec. 14, T.4N, R.18E SE¼ SW¼ Sec. 30, T.5N, R.19E	120		 17,200 3,300 1,150	Irrigation and domestic	Pending
12490	4/28/48	Oakdale and South San Joaquin Irrigation Districts	Middle Fork of Stanislaus River	NE¼ SE¼ Sec. 35, T.6N, R.18E			70,000	Irrigation	Permit
12497	5/ 3/48	Tuolumne County Water District No. 2	South Fork of Stanislaus River Herring Creek	NE¼ SW¼ Sec. 9, T.4N, R.19E SE¼ NW¼ Sec. 14, T.4N, R.18E SE¼ SW¼ Sec. 24, T.3N, R.16E SE¼ SW¼ Sec. 30, T.5N, R.19E	 100		17,200 3,300 1,150	Power	Pending
12498	5/ 3/48	Tuolumne County Water District No. 2	South Fork of Stanislaus River	SE¼ SW¼ Sec. 24, T.3N, R.16E	4			Municipal	Pending
12537	6/ 7/48	Calaveras County Water District	Black Creek	NE¼ NW¼ Sec. 1, T.1N, R.12E			5,000	Irrigation and domestic	Pending
12550	6/16/48	Fly In Lodges, Incorporated	Moran Creek	SW¼ NW¼ Sec. 33, T.5N, R.15E	0.1		45	Recreation	Permit
12614	7/23/48	Oakdale and South San Joaquin Irrigation Districts	Middle Fork of Stanislaus River	SW¼ NE¼ Sec. 14, T.4N, R.17E	550		100,000	Power	Pending
12659	8/19/48	E. Alford	Love Creek	NE¼ NE¼ Sec. 4, T.4N, R.15E			24	Irrigation and stockwatering	Permit
12739	10/ 8/48	Boy Scouts of America	Unnamed spring	NE¼ SE¼ Sec. 20, T.4N, R.18E		7,200		Domestic and irrigation	Permit

TABLE 10—Continued

APPLICATIONS TO APPROPRIATE WATER FROM STANISLAUS RIVER AND TRIBUTARIES, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion		Storage, in acre-feet	Purpose	Status
					in second-feet	in gallons per day			
12860	12/16/48	Tuolumne County Water District No. 2	North Fork of Stanislaus River Middle Fork of Stanislaus River	SE¼ NE¼ Sec. 4, T.6N, R.17E SE¼ NE¼ Sec. 4, T.6N, R.17E SE¼ NW¼ Sec. 23, T.6N, R.16E	600		 47,000 32,000	Power	Pending
12871	12/21/48	County of Tuolumne	South Fork of Stanislaus River	SW¼ SW¼ Sec. 15, T.4N, R.18E NE¼ SW¼ Sec. 14, T.4N, R.18E	1.0		 3,300	Municipal	Pending
12873	12/22/48	Oakdale and South San Joaquin Irrigation Districts	Middle Fork of Stanislaus River	NE¼ SE¼ Sec. 35, T.6N, R.18E	400		70,000	Power	Permit
12910	1/25/49	Calaveras County Water District	North Fork of Stanislaus River	SE¼ NW¼ Sec. 23, T.6N, R.16E	400			Irrigation and domestic	Pending
12911	1/25/49	Calaveras County Water District	North Fork of Stanislaus River	SE¼ NE¼ Sec. 4, T.6N, R.17E SE¼ NE¼ Sec. 23, T.6N, R.16E SW¼ NE¼ Sec. 35, T.5N, R.15E SE¼ NE¼ Sec. 4, T.6N, R.17E SE¼ NW¼ Sec. 23, T.6N, R.16E	400		 47,000 31,500	Power	Pending
12912	1/25/49	Calaveras County Water District	North Fork of Stanislaus River	Sec. 23, T.6N, R.17E	10			Municipal	Pending
13011	3/31/49	County of Tuolumne	Highland Creek	SE¼ SW¼ Sec. 3, T.6N, R.18E			60,000	Power	Pending
13012	3/31/49	County of Tuolumne	South Fork of Stanislaus River	SE¼ SW¼ Sec. 24, T.3N, R.16E			126,300	Irrigation	Pending
13091	5/13/49	Calaveras County Water District	Highland Creek	SE¼ SW¼ Sec. 3, T.6N, R.18E			63,000	Irrigation, incidental domestic, and stockwatering	Pending
13092	5/13/49	Calaveras County Water District	Highland Creek	SE¼ SW¼ Sec. 3, T.6N, R.18E			63,000	Power	Pending
13093	5/13/49	Calaveras County Water District	Highland Creek	SE¼ SW¼ Sec. 3, T.6N, R.18E			63,000	Municipal	Pending
13211	7/ 7/49	Oakdale and South San Joaquin Irrigation Districts	North Fork of Stanislaus River	SW¼ SE¼ Sec. 20, T.7N, R.18E SW¼ SW¼ Sec. 3, T.6N, R.18E	180		70,000	Irrigation	Incomplete
13212	7/ 7/49	Oakdale and South San Joaquin Irrigation Districts	North Fork of Stanislaus River	SW¼ SE¼ Sec. 20, T.7N, R.18E	180		70,000	Power	Incomplete
13245	7/21/49	County of Calaveras	North Fork of Stanislaus River	Sec. 23, T.6N, R.16E Sec. 3, T.6N, R.17E			50,000	Irrigation, incidental domestic, and stockwatering	Incomplete
13246	7/21/49	County of Calaveras	North Fork of Stanislaus River	NE¼ SW¼ Sec. 14, T.6N, R.16E	400		300,000	Irrigation and incidental domestic	Incomplete
13247	7/21/49	County of Calaveras	North Fork of Stanislaus River	NE¼ SW¼ Sec. 14, T.6N, R.16E	400		300,000	Municipal	Incomplete
13248	7/21/49	County of Calaveras	Highland Creek	SE¼ SW¼ Sec. 3, T.6N, R.18E			100,000	Municipal	Incomplete
13250	7/21/49	County of Calaveras	North Fork of Stanislaus River	NE¼ SW¼ Sec. 14, T.6N, R.16E	400		300,000	Power	Incomplete
13251	7/21/49	County of Calaveras	Black Creek	SE¼ NE¼ Sec. 26, T.2N, R.12E			5,000	Irrigation and incidental domestic	Incomplete
13252	7/21/49	County of Calaveras	Highland Creek	SE¼ SW¼ Sec. 3, T.6N, R.18E			100,000	Irrigation, incidental domestic, and stockwatering	Incomplete
13253	7/21/49	County of Calaveras	Highland Creek	SE¼ SW¼ Sec. 3, T.6N, R.18E			100,000	Power	Incomplete
13309	8/22/49	Oakdale and South San Joaquin Irrigation Districts	Middle Fork of Stanislaus River	NE¼ SE¼ Sec. 35, T.6N, R.18E	200			Power	Permit
13310	8/22/49	Oakdale and South San Joaquin Irrigation Districts	Stanislaus River	Lot 5 Sec. 1, T.1S, R.12E	1,500		80,000	Power	Permit
13353	9/14/49	Lewis and Mary Sherman	Unnamed stream	SE¼ NW¼ Sec. 23, T.7N, R.17E	0.0063		2.0	Domestic, irrigation, and recreational	Permit
13517	12/27/49	Boy Scouts of America	Unnamed creek	NE¼ NW¼ Sec. 7, T.4N, R.15E			35	Recreational	Permit
13833	7/ 5/50	United States—Stanislaus National Forest	Unnamed stream	NE¼ SW¼ Sec. 22, T.6N, R.19E	0.01			Domestic	Permit
14180	3/ 7/51	Calaveras County Water District	Mill Creek	SE¼ SE¼ Sec. 18, T.4N, R.15E	0.067			Domestic	Permit
14275	4/30/51	F. D. Addis	Mill Creek	SW¼ SE¼ Sec. 18, T.4N, R.15E	0.40			Domestic, irrigation, and recreational	Permit
14320	5/23/51	Tuolumne County Water District	South Fork of Stanislaus River	SW¼ NW¼ Sec. 22, T.4N, R.18E			25,000	Irrigation and domestic	Pending
14373	6/28/51	Tuolumne County Water District No. 2	Middle Fork of Stanislaus River	NE¼ SE¼ Sec. 35, T.6N, R.18E NE¼ SW¼ Sec. 2, T.5N, R.20E NE¼ SE¼ Sec. 35, T.6N, R.18E	600		 20,000 70,000	Power	Incomplete
14374	6/28/51	Oakdale and South San Joaquin Irrigation Districts	Middle Fork of Stanislaus River	NE¼ SW¼ Sec. 2, T.5N, R.20E			20,000	Irrigation	Incomplete
14375	6/28/51	Oakdale and South San Joaquin Irrigation Districts	Middle Fork of Stanislaus River	NE¼ SW¼ Sec. 2, T.5N, R.20E			20,000	Power	Incomplete

TABLE 10—Continued

APPLICATIONS TO APPROPRIATE WATER FROM STANISLAUS RIVER AND TRIBUTARIES, NOVEMBER 1, 1953

Application number	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian	Diversion in second-feet	Diversion in gallons per day	Storage, in acre-feet	Purpose	Status
14382	7/ 5/51	County of San Joaquin	Stanislaus River	SE¼ SW¼ Sec. 11, T.1N, R.13E			400,000	Domestic and irrigation	Permit
14576	11/13/51	Fly In Lodges, Incorporated	Moran Creek	SE¼ NE¼ Sec. 32, T.5N, R.15E	0.15		55	Recreational	Permit
14858	6/16/52	State of California, Department of Finance	Stanislaus River	SE¼ SE¼ Sec. 10, T.1N, R.13E	8,800		980,000	Irrigation, domestic, and flood control	Incomplete
14859	6/16/52	State of California, Department of Finance	Stanislaus River	SE¼ SE¼ Sec. 10, T.1N, R.13E	8,800		980,000	Power	Incomplete
14883	6/30/52	United States—Stanislaus National Forest	Lower Highland Lake	NW¼ SE¼ Sec. 32, T.8N, R.20E			140	Recreational	Permit
14898	11/ 9/52	K. E. Beard Company	Five Mile Creek	NE¼ NW¼ Sec. 1, T.2N, R.15E	0.02		25	Recreational	Permit
14976	8/18/52	Lloyd Burgess Darby	Unnamed spring	NW¼ SE¼ Sec. 24, T.4N, R.14E	0.08			Domestic and irrigation	Permit
15208	2/24/53	Harry L. Ball	2 unnamed mining tunnels	SW¼ NW¼ Sec. 25, T.3N, R.13E; NW¼ SW¼ Sec. 25, T.3N, R.13E		3,000		Domestic and stockwatering	Pending
15583	10/23/53	E. H. Wilson	Unnamed gulch	SE¼ SE¼ Sec. 32, T.3N, R.13E	0.5			Irrigation	Pending

APPENDIX H

DAMS UNDER STATE SUPERVISION IN AND ADJACENT TO SAN JOAQUIN AREA, 1952

DAMS UNDER STATE SUPERVISION IN AND ADJACENT TO SAN JOAQUIN AREA, 1952

Name	Owner	County	Stream	Location M. D. B. & M. Section	Township	Range
STATE OF CALIFORNIA						
Henderson	Preston School of Industry	Amador	Mule Creek	9	6N.	10E.
Henderson Forebay	Preston School of Industry	Amador	Tributary Sutter Creek	18	6N.	10E.
Preston	Youth Authority	Amador	Tributary Mule Creek	24	6N.	9E.
MUNICIPAL AND DISTRICT						
Hogan	City of Stockton	Calaveras	Calaveras River	31	4N.	11E.
Pardee	East Bay Municipal Utility District	Amador	Mokelumne River	26	5N.	10E.
Goodwin	Oakdale & South San Joaquin Irrigation Districts	Calaveras	Stanislaus River	10	1S.	12E.
Melones	Oakdale & South San Joaquin Irrigation Districts	Calaveras	Stanislaus River	11	1N.	13E.
Bingham	Calaveras Public Utility District	Calaveras	North Fork Calaveras River	36	6N.	13E.
Woodbridge Diversion	Woodbridge Irrigation District	San Joaquin	Mokelumne River	34-35	4N.	6E.
Middle Fork	Calaveras Public Utility District	Calaveras	Middle Fork Mokelumne River	9	6N.	13E.
Woodward	South San Joaquin Irrigation District	Stanislaus	Simmons Creek	9	1S.	10E.
Salt Springs Valley	Rock Creek Water District	Calaveras	Rock Creek	16	2N.	11E.
POWER COMPANY						
Bear River	Pacific Gas & Electric Co.	Amador	Bear River	9	8N.	16E.
Lower Blue Lake	Pacific Gas & Electric Co.	Alpine	Blue Creek	30	9N.	19E.
Meadow Lake	Pacific Gas & Electric Co.	Alpine	Tributary North Fork Mokelumne River	27	9N.	18E.
Salt Springs	Pacific Gas & Electric Co.	Amador	North Fork Mokelumne River	33	8N.	16E.
Lake Tabeaud	Pacific Gas & Electric Co.	Amador	Jackson Creek	28	6N.	12E.
Twin Lakes	Pacific Gas & Electric Co.	Alpine	Tributary North Fork Mokelumne River	25	9N.	18E.
Upper Blue Lake	Pacific Gas & Electric Co.	Alpine	Blue Creek	18	9N.	19E.
Tiger Creek Regulator	Pacific Gas & Electric Co.	Amador	Tiger Creek	8	7N.	14E.
Tiger Creek Afterbay	Pacific Gas & Electric Co.	Amador	North Fork Mokelumne River	23	7N.	13E.
Electra Diversion	Pacific Gas & Electric Co.	Amador	North Fork Mokelumne River	33	7N.	13E.
Silver Valley	Pacific Gas & Electric Co.	Alpine	Tributary North Fork Mokelumne River	9	7N.	18E.
Hunters	Pacific Gas & Electric Co.	Calaveras	Mill Creek	18	4N.	15E.
Ross	Pacific Gas & Electric Co.	Calaveras	San Domingo Creek	14	3N.	13E.
Union	Pacific Gas & Electric Co.	Alpine	North Fork Stanislaus River	28	7N.	18E.
Spicers Meadow	Pacific Gas & Electric Co.	Tuolumne	Highland Creek	3	6N.	18E.
Utica	Pacific Gas & Electric Co.	Alpine	North Fork Stanislaus River	21	7N.	18E.
PRIVATE						
Penn Mining Co.	Henry G. Kreth	Amador		33	5N.	10E
Emery	Calaveras Development Co.	Calaveras	McKinneys Creek	35	5N.	13E
Bevanda	V. R. Smith	Calaveras	Tributary Calaveras River	4	3N.	10E.
Maskus	Fred M. Seeman	Calaveras	Tributary Mokelumne River	2	4N.	10E.
Copperopolis	F. T. Hanchett	Calaveras	Penney Creek	33	2N.	12E.
Wallace	Gold Gravel Products Co.	Calaveras	Tributary Mokelumne River	15	4N.	9E
McCarty	McCarty Estate	Calaveras	Tributary Johnny Creek	18	2N.	12E
Mountain King	C. W. Stewart and Claude Nuss	Calaveras	Clover Creek	30	2N.	12E
Calaveras Cement Co.	Calaveras Cement Co.	Calaveras	South Fork Calaveras River	32	4N.	12E.
Christensen No. 1	Neal H. Christensen	Calaveras	Steel Creek	7	3N.	12E.
Gilmore	Greenlaw Grupe	San Joaquin	Tributary Mormon Slough	9	2N.	9E.
Davis	F. Podesta & F. Ferroggiaro	San Joaquin	Shaw Creek	6	2N.	9E.

DAMS UNDER STATE SUPERVISION IN AND ADJACENT TO SAN JOAQUIN AREA, 1952—Continued

Name	Type	Crest length, in feet	Crest height above stream, in feet	Elevation crest above sea level, in feet	Maximum storage capacity, in acre-feet	Year constructed	Use
STATE OF CALIFORNIA							
Henderson	Earth	630	56	787	469	1923	Power and irrigation
Henderson Forebay	Earth	190	40	624	30	1892	Power
Preston	Earth	647	40	360	268	1949	Irrigation
MUNICIPAL AND DISTRICT							
Hogan	Variable radius arches	1,366	125	654	76,000	1930	Flood control and irrigation
Pardee	Gravity curved	1,337	345	575	210,000	1929	Power and domestic
Goodwin	Two constant radius arch	450	74	350	200	1912	Irrigation
Melones	Arch	590	186	723	112,500	1926	Power and irrigation
Bingham	Earth	850	31	2,750	775	1882	Domestic
Woodbridge Diversion	Buttress, flashboards	240	31.5	48	2,464	1910	Irrigation
Middle Fork	Earth	600	95	3,035	1,718	1939	Domestic
Woodward	Hydraulic fill	3,100	65	215	35,000	1918	Irrigation
Salt Springs Valley	Earth	2,150	46	1,178	10,900	1882	Irrigation
POWER COMPANY							
Bear River	Rockfill	780	75	5,879	6,712	1910	Power
Lower Blue Lake	Earth, rockwall	1,050	43	8,040	4,300	1903	Power
Meadow Lake	Rockfill	775	73	7,773	5,850	1903	Power
Salt Springs	Rockfill	1,300	285	3,960	139,400	1931	Power
Lake Tabeaud	Earth	645	123	1,968	1,165	1901	Power
Twin Lakes	Earth, rockwall	1,260	22	8,172	1,300	1901	Power
Upper Blue Lake	Earth, rockwall	790	31	8,131	7,500	1901	Power
Tiger Creek Regulator	Slab and buttress	470	100	3,588	540	1931	Power
Tiger Creek Afterbay	Variable radius arch	450	105	2,340	3,960	1931	Power
Electra Diversion	Gravity, straight	180	44	2,045	65	1947	Power
Silver Valley	Masonry, rockfill	280	45	7,270	4,600	1906	Power
Hunters	Constant radius arch	370	43	3,205	200	1928	Power
Ross	Masonry arch	270	45	2,000	85	1895	Power
Union	Masonry, rockfill	705	34	6,820	2,000	1902	Power
Spicers Meadow	Gravity, straight	250	53	6,421	3,800	1929	Power
Utica	Dry rubble, gravity	330	52	6.775	2,400	1908	Power
PRIVATE							
Penn Mining Co.	Earth	365	31	400	62	1939	Mining
Emery	Earth	425	51	2,500	400	1850	Mining
Bevanda	Earth	610	29	400	60	1925	Irrigation
Maskus	Earth	300	24	800	60	?	Irrigation
Copperopolis	Earth and masonry	660	33	975	225	1905	Domestic
Wallace	Gravel	800	71	300	3,000	1944	Mining
McCarty	Earth	738	17.5	1,150	93	1938	Industrial
Mountain King	Earth	280	30	1,025	82	1938	Industrial
Calaveras Cement Co.	Concrete abutment, flashboards	247	17	828	36	1926	Industrial
Christensen No. 1	Earth	750	33	1,565	69	1951	Irrigation
Gilmore	Earth	1,080	28	170	500	1918	Irrigation
Davis	Earth	2,200	13	115	500	1917	Irrigation

APPENDIX I

RESULTS OF LAND USE SURVEYS IN SAN JOAQUIN AREA

RESULTS OF LAND USE SURVEYS IN SAN JOAQUIN AREA

(In acres)

Class and type of land use	1949				1950	1951
	Western Mokelumne Unit	Eastern Mokelumne Unit	Calaveras Unit	Littlejohns Unit	Littlejohns Unit	Littlejohns Unit
Irrigated Lands						
Permanent pasture	16,560	9,510	3,930	17,130	18,530	19,000
Deciduous orchard	1,750	3,970	17,540	1,940	1,940	1,940
Vineyard	14,380	27,850	210	220	220	230
Alfalfa	3,950	1,500	2,490	2,590	3,360	3,040
Beans	220	790	9,170	180	230	430
Tomatoes	2,680	1,920	5,720	900	520	1,900
Rice	760	40	700	5,280	3,570	4,940
Truck	1,670	1,500	2,510	260	200	140
Asparagus	2,800	------	------	------	------	------
Sugar beets	580	850	1,080	220	300	340
Miscellaneous	------	------	------	670	980	490
Subtotals	45,350	47,930	43,350	29,390	29,850	32,450
Dry-Farmed and Fallow Lands	22,190	51,420	26,900	61,600	60,840	57,850
Native Vegetation	710	3,490	260	280	280	280
Miscellaneous						
Urban	1,130	1,950	11,360	500	760	1,010
Farmsteads	1,050	1,690	1,220	600	620	640
Roads	1,060	1,700	1,180	660	670	700
Highways and railroads	1,020	1,490	650	1,330	1,340	1,430
Water surface	760	740	510	100	100	100
Waste land	40	390	540	------	------	------
Swamps	160	------	------	------	------	------
Subtotals	5,220	7,960	15,460	3,190	3,490	3,880
TOTALS	73,470	110,800	85,970	94,460	94,460	94,460

APPENDIX J

RECORDS OF APPLICATION OF GROUND WATER TO REPRESENTATIVE CROPS IN SAN JOAQUIN AREA

APPLICATION OF GROUND WATER TO REPRESENTATIVE CROPS IN SAN JOAQUIN AREA IN 1948, 1949, 1950, AND 1951

Crop	Season	Map number	Well number	Soil type	Acres	Depth per month, in inches: Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total depth, in inches
Alfalfa	1948	1	2N/6E-13L2	Clay, very low permeability	1					11.5	4.6		32.3			48.4
	1948	2	2N/7E-5K1	Clay, very low permeability	31			3.8	3.8	3.7	6.8	7.4	6.9			32.4
	1948	3	2N/7E-26E1	Clay	14		10.1		1.4	10.6	9.4	9.0	6.7			47.2
	1948	4	3N/8E-32P1	Clay, poorly drained	5				2.5	4.5	2.2	5.2	2.6			17.0
	1949	3	2N/7E-26E1	Clay	14				12.2	7.1	9.4	16.2	11.8			56.7
	1949	5	2N/9E-5N1	Fine sandy loam	20			4.9	6.1	3.9	3.9	5.5	3.7			28.0
	1949	6	3N/6E-8F1	Sandy loam	39			3.1	3.4	7.8	6.4	4.5	2.8			28.0
	1949	7	3N/6E-8J1	Sandy loam	38				5.8	9.9	8.9	1.6				26.2
	1949	8	3N/7E-13K1	Loam, deep	46				8.7	3.1	2.8	7.7	5.3	3.4		31.0
	1949	4	3N/8E-32P1	Clay, poorly drained	5				2.4	5.8	2.6	2.3	4.3			17.4
	1949	9	4N/5E-13R1	Sandy loam	80				11.5	6.4	10.5	8.7	5.0	3.7		45.8
	1950	10	1S/8E-29E1	Sandy loam	76			2.1	13.2	6.0	7.3	11.6	8.0	7.7		55.9
	1950	11	1S/8E-29H1	Sandy loam	58				17.7	10.5	5.6	15.9	6.0	12.8		68.5
	1950	12	1S/7E-3R1	Clay, low permeability	42				15.3	7.1	12.2	6.1	6.1	5.0		51.8
	1950	13	1N/7E-25P1	Clay, low permeability	50				6.3	3.2	5.9	6.4				21.8
	1950	6	3N/6E-8F1	Sandy loam	39				10.3	8.4	6.2	9.2	2.8			36.9
	1950	7	3N/6E-8J1	Sandy loam	38				8.7	11.0	5.1	11.4	3.1			39.3
	1951	12	1S/7E-3R1	Stockton clay, very low permeability	42					5.1	7.8	8.9	4.8			26.6
	1951	10	1S/8E-29E1	Loam, moderate permeability	76				15.9	11.9	14.9	14.3	9.8	14.4		81.2
	1951	11	1S/8E-29H1	Loam, moderate permeability	58				7.3	13.1	8.1	8.2	4.4			41.1
	1951	13	1N/7E-25P1	Clay soil, low permeability	50			1.4	4.0	6.4	3.3	4.8	7.4			27.3
	1951	14	1N/8E-23M1	Clay soil, low permeability	85			3.2	3.7	5.8	9.7	14.2	10.3	2.5		49.4
	1951	15	1N/8E-33F1	Clay soil, low permeability	116			.1	5.6	7.7	6.8	8.0	6.9			35.1
									Weighted mean depths:							
									1948 35.4 inches (3.0 feet)							
									1949 35.6 inches (3.0 feet)							
									1950 47.4 inches (4.0 feet)							
									1951 45.2 inches (3.8 feet)							
									1948-1951 43.1 inches (3.6 feet)							
Almonds	1949	16	3N/6E-8A1	Sandy loam	10			6.5	12.1	7.9						26.5
									Weighted mean depth:							
									1949 26.5 inches (2.2 feet)							
Beans	1948	17	2N/7E-2A1	Adobe clay, poorly drained	37						15.6	8.9	0.4			24.9
	1948	18	2N/8E-11C1	Silt loam	9					5.4		6.8	5.0			17.2
	1948	19	2N/8E-13K1	Clay loam	68					5.8	2.0	5.9	1.0			14.7
	1948	20	2N/8E-28D1	Silt loam	80					9.6	4.2	9.7	4.4			27.9
	1948	21	3N/8E-32P1	Clay, poorly drained	74					5.8	2.3	4.8	1.9			14.8
	1949	22	2N/8E-12E1	Silt loam	70					10.4	3.0	5.6	1.0	1.5		21.5
	1949	23	2N/8E-29G1	Clay loam	78					6.2	4.4	6.1	4.0			20.7
	1949	24	3N/7E-33E1	Clay loam	72			.8	4.3	4.7	2.3	6.2	2.3			20.6
	1949	21	3N/8E-32P1	Clay, poorly drained	74					8.4		8.5	1.1			18.0
	1950	26	1S/8E-16B1	Adobe clay	65				7.7	5.1	2.8	10.1	1.4			27.1
									Weighted mean depths:							
									1948 20.2 inches (1.7 fect)							
									1949 20.2 iuches (1.7 feet)							
									1950 27.1 inches (2.3 feet)							
									1948-1950 20.9 inches (1.7 feet)							
Cabbage	1948	27	2N/6E-26L1	Adobe clay	5					5.0	7.6	6.0	6.4	1.2		26.2
									Weighted mean depth:							
									1948 26.2 inches (2.2 fcet)							
Cauliflower	1948	28	2N/6E-26L1	Adobe clay	5							17.0	7.9	9.1	3.0	37.0
									Weighted mean depth:							
									1948 37.0 inches (3.1 fcet)							
Cherries	1948	25	2N/7E-22D2	Clay loam	2					9.4	8.6	11.0	7.8			45.1
	1949	30	2N/7E-15J1	Sandy loam	15			5.4	3.4	3.5	14.2	4.6				31.1
	1949	56	4N/6E-22L1	Sandy loam, poorly drained	15			18.0	6.7	13.3	13.3					52.3
									Weighted mean depths:							
									1948 45.1 inches (3.8 feet)							
									1949 41.7 inches (3.5 feet)							
									1948-1949 42.0 inches (3.5 feet)							
Egyptian corn	1948	29	2N/6E-13K1	Adobe clay, low permeability	80						4.2	12.7	0.7			17.6
									Weighted mean depth:							
									1948 8.8 inches (.7 feet)							

APPLICATION OF GROUND WATER TO REPRESENTATIVE CROPS IN SAN JOAQUIN AREA IN 1948, 1949, 1950, AND 1951—Continued

Crop	Season	Map number	Well number	Soil type	Acres	Depth per month, in inches										Total depth, in inches
						Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	
Lettuce	1948	31	2N/6E-26L1	Adobe clay	13				0.7				10.5	1.1		12.3
									Weighted mean depth: 1948 12.3 inches (1.0 feet)							
Nectarines and peaches	1949	32	2N/8E-4B1	Clay loam	42				4.8	6.2	6.1	4.8				21.9
									Weighted mean depth: 1948 21.9 inches (1.8 feet)							
Onions	1948	33	2N/6E-26L1	Adobe clay	2							3.0	30.3	18.2	7.6	59.1
									Weighted mean depth: 1948 59.1 inches (4.9 feet)							
Orchard, mixed deciduous	1951	34	1N/8E-25G2	Clay	34				2.7	2.4	6.9	6.7				18.7
									Weighted mean depth: 1951 18.7 inches (1.6 feet)							
Pasture	1948	35	2N/7E-5H1	Clay loam	85				3.6	3.7	8.3	8.2	3.8	.8		28.4
	1948	36	2N/7E-26E1	Clay	24		5.9		5.9	8.5	10.6	10.1	8.0	1.7	3.5	54.2
	1948	37	2N/7E-36R1	Adobe clay	20			3.9	4.1	7.2	6.2	7.6	6.6	3.3		38.9
	1948	38	2N/8E-25P1	Loam	260		3.9	1.0	3.0	4.7	6.0	5.8	4.1	3.3	0.8	32.6
	1949	35	2N/7E-5H1	Adobe clay	85			3.3	5.7	6.5	7.0	7.4	5.0			34.9
	1949	36	2N/7E-26E1	Clay	24			4.8	7.1	14.8	9.3	8.3	10.8	8.5		63.6
	1949	38	2N/8E-25P1	Loam	230			5.2	6.3	8.3	8.8	8.1	6.6	4.9		48.2
	1949	39	3N/6E-34J1	Clay loam	80			8.2	7.1	10.4	11.0	6.6	7.1	4.4		54.8
	1949	40	4N/7E-6R1	Loam	75			2.5	5.9	9.3	8.1	8.0	6.4	2.1		42.3
	1949	41	5N/7E-34C1	Loam	20			3.1	5.3	9.3	7.1	6.2	5.3	6.2	1.8	44.3
	1950	42	1N/7E-34A1 1N/7E-34B1	Adobe clay	48		4.3	4.8	8.3	8.9	9.7	14.4	5.2			55.6
	1950	43	1N/9E-25B1	Clay	60			3.9	8.8	8.6	13.5	9.6	9.6	4.0		58.0
	1950	44	3N/7E-23M1	Adobe clay	110			2.6	4.3	4.1	4.6	4.8	3.6			24.0
	1950	41	5N/7E-34C1	Loam	20			2.7	6.5	6.9	8.8	5.8	5.8	1.9		38.4
	1951 1951	45	1S/8E-5E1 1S/8E-6A1	Adobe clay	225			2.4	8.6	9.8	8.4	11.8	6.2	4.1		51.3
	1951	46	1S/8E-11B1	Sandy loam	30				12.9	17.3	15.3	22.8	15.0	4.2		87.5
	1951	47	1S/8E-13C1	Sandy loam	36			.7	7.6	8.7	9.7	11.1	6.8	4.2		48.8
	1951	48	1S/9E-11M1	Sandy and gravelly loam	105			1.3	6.8	6.5	9.7	1.8	3.5	6.2		35.8
	1951	49	1S/9E-20E2	Sandy loam	24			2.6	2.8	10.6	10.8	5.8	6.7	2.6		41.9
	1951	50	1N/7E-21J1	Adobe clay	10			2.2	5.5	7.9	11.2	9.7	6.1	3.7		46.3
	1951 1951	42	1N/7E-34A1 1N/7E-34B1	Adobe clay	102			3.9	9.0	11.6	10.8	7.5	7.6	2.1		52.5
	1951	51	1N/8E-13R1	Clay loam, poorly drained	29			1.2	4.9	5.3	6.3	6.7	4.6	2.3		31.3
	1951	52	1N/8E-34R2	Adobe clay	41			5.2	8.8	13.3	10.8	12.5	6.7	3.4		60.7
									Weighted mean depths: 1948 33.3 inches (2.8 feet) 1949 46.7 inches (3.9 feet) 1950 40.2 inches (3.3 feet) 1951 49.7 inches (4.1 feet) 1948-1951 43.9 inches (3.6 feet)							
Peaches	1948	53	2N/7E-22D2	Clay loam	21		8.3			9.4	8.6	11.0	7.8			45.1
	1948	54	2N/8E-18B1	Clay loam	65				17.1	8.5	10.6	6.0	4.9			47.1
	1948	55	2N/8E-28D1 2N/8E-28D2	Silt loam	9		1.5			11.3	16.2	7.7	11.1			47.8
	1949	54	2N/8E-18B1	Clay loam	65			6.1		11.6	7.5	4.6	1.4	1.9	3.5	36.6
									Weighted mean depths: 1948 46.7 inches (3.9 feet) 1949 36.6 inches (3.0 feet)							
Peaches and cherries (young)	1949	57	2N/8E-4B1	Clay loam	43				5.7	3.1	8.3	6.7				23.8
									Weighted mean depth: 1949 23.8 inches (2.0 feet)							
Peaches and plums	1949	58	4N/7E-23K1	Sandy loam	79			1.3	4.4	4.0	4.6	2.2	5.3	.2		22.0
									Weighted mean depth: 1949 22.0 inches (1.8 feet)							

APPLICATION OF GROUND WATER TO REPRESENTATIVE CROPS IN SAN JOAQUIN AREA IN 1948, 1949, 1950, AND 1951—Continued

Crop	Season	Map number	Well number	Soil type	Acres	Depth per month, in inches										Total depth, in inches
						Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	
Plums	1949	59	4N/6E-20H1	Sandy loam	40				8.2	8.9						17.1
	1950	60	1N/9E-25B1	Clay	25				7.7	6.9	9.2	11.9				35.7
	1950	59	4N/6E-20H1	Sandy loam	40				13.4	8.9						22.3
									Weighted mean depths:							
									1949 17.1 inches (1.4 feet)							
									1950 27.5 inches (2.3 feet)							
									1949-50 23.6 inches (2.0 feet)							
Potatoes	1948	61	2N/6E-26L1	Adobe clay	14				5.8	9.3	5.6					20.7
									Weighted mean depth:							
									1948 20.7 inches (1.7 feet)							
Rice	1948	62	1N/7E-9Q1	Clay loam	170				11.7	21.6	22.1	21.6	20.8			97.8
	1948		1N/7E-16D1													
	1950	63	1S/8E-5M1	Adobe clay	125				22.7	27.0	37.3	40.2	21.1			148.3
	1950		1S/8E-5R1													
	1951	64	1S/8E-8B1	Adobe clay	157				19.0	21.5	22.6	44.9	21.3			129.3
			1S/8E-8F1													
	1951	65	1N/7E-27M1	Adobe clay	56					22.7	26.9	44.9	29.3			123.5
	1951	66	1N/7E-28M1	Adobe clay	82					23.5	21.0	27.0	10.7			82.2
	1951	67	1N/8E-36D1	Adobe clay	162			10.9	10.1	13.2	16.8	22.6				73.6
			1N/8E-36H1													
									Weighted mean depths:							
									1948 97.8 inches (8.2 feet)							
									1950 148.3 inches (12.4 feet)							
									1951 100.4 inches (8.4 feet)							
									1948-1951 107.8 inches (9.0 feet)							
Squash	1948	68	2N/6E-26L1	Adobe clay	.5					22.7	6.1					28.8
									Weighted mean depth:							
									1948 28.8 inches (2.4 feet)							
Sugar beets	1948	23	2N/8E-29G1	Clay loam	78					6.1	5.1	6.9	1.5			19.6
	1949	69	1N/6E-16H1	Silty clay	45			5.0	8.0	14.9	11.5	.6				40.0
	1949	17	2N/7E-2A1	Adobe clay, poorly drained	40			1.4	3.4	4.3	5.6	4.7	2.2			21.6
	1949	70	2N/7E-4C2	Adobe clay	48				4.7	2.3	5.8	13.5	3.5			29.8
	1949	19	2N/8E-13K1	Clay loam	68				3.7	7.2	8.9	4.5				24.3
	1949	71	2N/8E-29M1	Clay	80				5.4	7.2	10.4	6.6	2.3			31.9
	1950	72	1S/7E-5D1	Adobe clay	97				1.3	6.5	5.8	5.2				18.8
									Weighted mean depths:							
									1948 19.6 inches (1.6 feet)							
									1949 29.5 inches (2.5 feet)							
									1950 18.8 inches (1.6 feet)							
									1948-1950 25.6 inches (2.1 feet)							
Tomatoes	1948	69	1N/6E-16H1	Silty clay	45				4.0	5.5	7.2	9.0	6.1			31.8
	1948	73	1N/7E-9L1	Adobe clay	38				1.7	3.2	4.2	7.0	2.8			18.9
	1948	74	2N/7E-5K1	Adobe clay	66				10.8	0.4	5.8	7.2	1.5			25.7
	1948	75	2N/7E-36R1	Adobe clay	50					2.2	7.1	6.1	4.3			19.7
	1949	76	2N/7E-4C2	Adobe clay	12				3.9	8.6	13.1	11.4				37.0
	1949	77	2N/7E-34N1	Adobe clay	80				2.3	3.3	5.3	6.0	1.0			17.9
	1949	78	3N/6E-29P1	Sandy loam	79				2.3	2.4	8.7	9.2	.7			23.3
	1950	78	3N/6E-29P1	Sandy loam	60				2.6	9.7	9.7	4.2				26.2
	1951	26	1S/8E-16B1	Adobe clay	102				7.4	2.3	3.1	3.5	5.1	1.5		22.9
	1951	79	1N/8E-27R3	Clay	20						.8	4.0	3.4			8.2
									Weighted mean depths:							
									1948 24.3 inches (2.0 feet)							
									1949 21.7 inches (1.8 feet)							
									1950 26.2 inches (2.2 feet)							
									1951 20.5 inches (1.7 feet)							
									1948-1951 23.3 inches (1.9 feet)							
Vineyard	1949	80	3N/6E-3C1	Sandy loam	24				.6	28.6	2.2					31.4
	1949	81	3N/6E-8A1	Sandy loam	28			1.5	10.1	3.2	5.9	.4				21.1
	1949	82	3N/6E-8E1	Sandy loam	39					9.4	14.6	2.1				26.1
	1949	83	3N/6E-13K1	Sandy loam	62				5.0	20.2	16.8					42.0
	1949	84	3N/7E-10F1	Sandy loam	79			7.3	5.8	2.6	.8	.5				17.0
	1949	85	4N/6E-10N2	Sandy loam	124					5.5	5.7	1.8	.2	3.8	2.8	19.8
	1949	86	4N/6E-13A2	Loam	39					3.9	3.9	4.9		.1	1.1	13.9
	1949	87	4N/6E-22K1	Sandy loam	24			.1		5.2	4.8	.9				11.0

APPLICATION OF GROUND WATER TO REPRESENTATIVE CROPS IN SAN JOAQUIN AREA IN 1948, 1949, 1950, AND 1951—Continued

Crop	Season	Map number	Well number	Soil type	Acres	Depth per month, in inches										Total depth, in inches
						Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	
Vineyard—Continued	1949	88	4N/7E-16M1	Loam and sandy loam	78				2.5	2.7	5.2	2.2				12.6
	1949	89	4N/7E-19H1	Sandy loam	38				4.3	5.6	4.3	1.8				16.0
	1949	90	4N/7E-23P1	Sandy loam	70			.1	4.9	5.9	2.2					13.1
	1949	91	4N/7E-30J1	Sandy loam	80			1.6	6.7	3.8	1.1					13.2
	1950	80	3N/6E-3C1	Sandy loam	24		18.5			18.5	3.2					40.2
	1950	83	3N/6E-13K1	Sandy loam	62				9.3	20.5	16.7					46.5
	1950	84	3N/7E-10F1	Sandy loam	79	1.1	6.5	10.4	1.1	1.6	1.4	.9				23.0
	1950	85	4N/6E-10N2	Sandy loam	124				3.3	5.6	2.9	3.0	.3			15.1
	1950	88	4N/7E-16M1	Loam and sandy loam	78				2.7	4.7	4.7	4.7				16.8
	1950	89	4N/7E-19H1	Sandy loam	38			10.7	4.0	11.1	11.6	5.8	1.3			44.5
	1950	91	4N/7E-30J1	Sandy loam	80			6.3	4.0	1.4	2.1	1.5				15.3

Weighted mean depths:
1949 19.2 inches (1.6 feet)
1950 24.1 inches (2.0 feet)
1949-1950 21.2 inches (1.8 feet)

Crop	Season	Map number	Well number	Soil type	Acres	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total depth, in inches
Walnuts	1948	101	1N/6E-5G3	Sacramento silty clay	5		6.2			7.3	7.1	7.0	0.1			27.7
	1948	93	2N/8E-7B1													
	1948	93	2N/8E-7C1													
	1948	93	2N/8E-7F1													
	1948	93	2N/8E-7K1	Clay and clay loam	593	14.5				1.6	8.4	7.8	3.3			35.6
	1948	93	2N/8E-7P1													
	1948	93	2N/8E-8J1													
	1948	93	2N/8E-8N1													
	1948	102	2N/8E-11C1	Silt loam	79					1.0	9.5	11.2	5.2			26.2
	1948	95	2N/8E-15A1	Wyman clay, poorly drained	40					3.3	10.4	5.1	2.1			20.9
	1948	103	2N/9E-5H1	Sandy loam	60						9.1	17.1				26.2
	1949	92	2N/7E-34B1	Adobe clay	25				6.9	5.4		4.8				17.1
	1949	93	2N/8E-7B1													
	1949	93	2N/8E-7C1													
	1949	93	2N/8E-7F1													
	1949	93	2N/8E-7K1	Clay and clay loam	593	4.1			7.9	3.8	9.5	10.2				35.5
	1949	93	2N/8E-7P1													
	1949	93	2N/8E-8J1													
	1949	93	2N/8E-8N1													
	1949	94	2N/8E-11B1	Silt loam	20				8.4		10.0	9.1				27.5
	1949	95	2N/8E-15A1	Wyman clay, poorly drained	40				8.4	6.2	2.6	11.4				28.6
	1949	96	3N/7E-21J1	Sandy loam	60				5.6	5.8	7.7	7.4				26.5
	1949	96	3N/7E-21K1													
	1950	97	1N/9E-25B1	Clay	18				4.4	4.9	12.6	4.4				26.3
	1950	98	1N/9E-25N1	Clay	120				3.7	10.2	6.6	12.5				33.0
	1950	96	3N/7E-21J1	Sandy loam	60		6.0	1.8		7.7	6.6	.6	7.1			29.8
	1950	96	3N/7E-21K1													
	1951	99	1N/9E-17H1	Adobe clay	18			.2	.9	6.8	6.6	4.9	.2	.1		19.7
	1951	100	1N/9E-30B4	Clay	28					7.6	3.0	9.2				19.8

Weighted mean depths:
1948 33.1 inches (2.8 feet)
1949 33.6 inches (2.8 feet)
1950 31.4 inches (2.6 feet)
1951 19.8 inches (1.6 feet)
1949-1951 32.5 inches (2.7 feet)

APPENDIX K

SUMMARIES OF MONTHLY YIELD STUDIES

11—19144

TABLE OF CONTENTS

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, IRISH HILL RESERVOIR ON DRY CREEK

(In acre-feet)

Storage capacity: 43,500 acre-feet

New irrigation yield: 20,000 acre-feet

Season	Water supply				Distribution of water supply				Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Runoff of Dry Creek at dam site	Diversion from Sutter Creek	Total storable inflow	Evaporation	Irrigation release	Spill	Storage, September 30	
1926-27	0	32,200	31,100	63,300	3,000	20,000	14,100	26,200	0
27-28	26,200	23,600	24,900	48,500	3,000	20,000	26,500	25,200	0
28-29	25,200	8,900	6,500	15,400	2,600	20,000	0	18,000	0
29-30	18,000	10,900	6,700	17,600	2,200	20,000	0	13,400	0
30-31	13,400	2,600	400	3,000	900	15,000	0	500	25
1931-32	500	25,600	18,400	44,000	2,800	18,600	0	23,100	7
32-33	23,100	3,100	1,600	4,700	1,600	20,000	0	6,200	0
33-34	6,200	8,200	5,800	14,000	1,000	18,700	0	500	6
34-35	500	24,900	18,800	43,700	2,700	18,600	0	22,900	7

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, IONE RESERVOIR ON DRY CREEK

(In acre-feet)

Storage capacity: 40,000 acre-feet

New irrigation yield: 21,000 acre-feet

Season	Water supply		Distribution of water supply				Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Inflow to reservoir	Evaporation	Irrigation release	Spill	Storage, September 30	
1927-28	0	69,100	7,300	21,000	24,100	16,700	0
28-29	16,700	22,200	6,300	21,000	0	11,600	0
29-30	11,600	29,800	6,800	21,000	0	13,600	0
30-31	13,600	4,600	1,800	15,400	0	1,000	27
31-32	1,000	76,200	7,200	19,500	35,500	15,000	7
1932-33	15,000	8,300	3,400	18,900	0	1,000	10
33-34	1,000	29,300	4,900	19,500	0	5,900	7
34-35	5,900	83,800	7,500	21,000	43,100	18,100	0

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, RAILROAD FLAT RESERVOIR ON SOUTH FORK OF MOKELUMNE RIVER

(In acre-feet)

Storage capacity: 80,000 acre-feet

New irrigation yield: 20,000 acre-feet

Season	Water supply		Distribution of water supply					Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Storable inflow to reservoir	Evaporation	Irrigation release	Fish release	Spill	Storage, September 30	
926-27	0	85,800	1,300	20,000	2,400	0	62,100	0
27-28	62,100	58,600	1,300	20,000	2,400	30,600	66,400	0
28-29	66,400	9,400	1,300	20,000	2,400	0	52,100	0
29-30	52,100	8,500	1,300	20,000	2,400	0	36,900	0
30-31	36,900	5,700	1,300	20,000	2,400	0	18,900	0
931-32	18,900	13,300	1,300	20,000	2,400	0	8,500	0
32-33	8,500	24,200	1,300	20,000	2,400	0	9,000	0
33-34	9,000	15,500	1,300	15,800	2,400	0	5,000	21
34-35	5,000	26,100	1,300	18,700	2,400	0	8,700	6

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, MIDDLE BAR RESERVOIR ON MOKELUMNE RIVER

(In acre-feet)

Storage capacity: 46,500 acre-feet — New irrigation yield: 11,000 acre-feet

Season	Water supply		Distribution of water supply				Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Storable inflow to reservoir	Evaporation	Irrigation release	Spill	Storage, September 30	
1927-28	0	288,100	1,900	11,000	238,200	37,000	0
28-29	37,000	0	1,500	11,000	0	24,500	0
29-30	24,500	0	1,000	11,000	0	12,500	0
30-31	12,500	0	400	9,100	0	3,000	17
31-32	3,000	104,900	1,400	7,600	59,200	39,700	31
1932-33	39,700	30,100	1,900	11,000	17,700	39,200	0
33-34	39,200	53,100	1,800	11,000	45,000	34,500	0
34-35	34,500	130,000	1,800	11,000	112,400	39,300	0

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, PARDEE RESERVOIR ON MOKELUMNE RIVER

(In acre-feet)

Storage capacity: 209,900 acre-feet — Yield: 381,000 acre-feet

Season	Water supply		Distribution of water supply				Seasonal irrigation deficiency, in per cent of seasonal yield
	Storage, October 1	Inflow to reservoir	Evaporation	Releases	Spill	Storage, September 30	
1927-28	0	655,000	5,400	381,000	95,900	172,700	0
28-29	172,700	328,200	6,700	381,000	0	113,200	0
29-30	113,200	427,400	5,400	381,000	0	154,200	0
30-31	154,200	241,600	3,600	375,400	0	16,800	1
31-32	16,800	651,500	5,900	362,600	104,900	194,900	5
1932-33	194,900	412,300	7,500	381,000	30,100	188,600	0
33-34	188,600	334,100	6,200	381,000	53,100	82,400	0
34-35	82,400	614,200	5,200	381,000	130,000	180,400	0

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, CAMANCHE RESERVOIR ON MOKELUMNE RIVER

(In acre-feet)

Storage capacity: 212,000 acre-feet — New irrigation yield: 52,000 acre-feet

Season	Water supply		Distribution of water supply				Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Storable inflow to reservoir	Evaporation	Irrigation release	Spill	Storage, September 30	
1927-28	0	297,300	18,200	52,000	69,100	158,000	0
28-29	158,000	4,600	14,700	52,000	0	95,900	0
29-30	95,900	9,800	9,500	52,000	0	44,200	0
30-31	44,200	2,900	3,000	41,100	0	3,000	21
31-32	3,000	127,500	5,000	48,400	0	77,100	7
1932-33	77,100	32,700	6,500	52,000	0	51,300	0
33-34	51,300	63,800	8,000	52,000	0	55,100	0
34-35	55,100	154,800	14,000	52,000	0	143,600	0

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, MEHRTEN RESERVOIR ON MOKELUMNE RIVER

(In acre-feet)

Storage capacity: 50,000 acre-feet — New irrigation yield: 13,700 acre-feet

Season	Water supply		Distribution of water supply				Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Storable inflow to reservoir	Evaporation	Irrigation release	Spill	Storage, September 30	
1927-28	0	297,300	7,000	13,700	243,900	33,700	0
28-29	33,700	4,600	5,300	13,700	0	19,300	0
29-30	19,300	9,800	4,200	13,700	0	11,200	0
30-31	11,200	2,900	3,300	9,800	0	1,000	28
31-32	1,000	127,500	5,600	12,700	72,500	37,700	7
1932-33	37,700	32,700	7,000	13,700	13,900	35,800	0
33-34	35,800	63,800	7,000	13,700	48,600	38,900	0
34-35	38,900	154,800	6,900	13,700	128,100	36,400	0

YEARLY SUMMARY OF MONTHLY YIELD STUDY, CLEMENTS AND LOCKEFORD DIVERSIONS

(In acre-feet)

Total diversion capacity: 250 second-feet — Average new yield: 31,000 acre-feet

Year	Releases from Pardee Reservoir	Present users below Pardee Reservoir	Surplus flow in Mokelumne River	Surplus flows in Mokelumne River, April through October	Number of months surplus flow available, April through October	Yield from project, April through October	Waste to Delta, April through October	Total waste to Delta
1924	88,100	74,000	14,100	0	0	0	0	14,100
1925	465,900	130,600	335,300	303,400	3	45,000	258,400	290,300
26	175,000	106,500	68,500	0	0	0	0	68,500
27	572,000	143,600	428,400	277,200	3	45,000	232,200	383,400
28	393,900	116,900	277,000	167,800	2	30,000	137,800	247,000
29	91,100	77,200	13,900	0	0	0	0	13,900
1930	189,400	122,700	66,700	22,500	1	15,000	7,500	51,700
31	68,900	68,900	0	0	0	0	0	0
32	373,900	142,600	231,300	207,600	3	45,000	162,600	186,300
33	175,200	125,100	50,100	12,200	2	12,200	0	37,900
34	127,000	79,200	47,800	0	0	0	0	47,800
1935	372,200	130,700	241,500	216,500	3	45,000	171,500	196,500
36	669,500	140,300	529,200	273,700	3	45,000	228,700	484,200
37	501,100	135,900	365,200	192,600	3	45,000	147,600	320,200
38	1,014,600	160,800	853,800	576,100	4	54,000	522,100	799,800
39	108,400	84,300	24,100	0	0	0	0	24,100
1940	640,900	136,100	504,800	265,300	3	45,000	220,300	459,800
41	583,400	145,800	437,600	241,600	3	45,000	196,600	392,600
42	754,600	158,900	595,700	366,600	4	51,200	315,400	544,500
43	775,800	148,300	627,500	321,600	3	45,000	276,600	582,500
44	215,400	124,700	90,700	4,300	1	4,300	0	86,400
1945	548,700	138,000	410,700	199,400	3	45,000	154,400	365,700
46	480,400	138,700	341,700	189,000	3	45,000	144,000	296,700
47	156,900	101,100	55,800	11,200	1	11,200	0	44,600
48	336,800	133,600	203,200	162,000	3	45,000	117,000	158,200
49	299,100	132,400	166,700	116,000	3	45,000	71,000	121,700
1950	897,200	93,600	803,600	257,300	4	60,000	197,300	743,600
51	618,000	141,100	476,900	187,200	3	35,300	151,900	441,600

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, NEW HOGAN RESERVOIR ON CALAVERAS RIVER

(In acre-feet)

Storage capacity: 315,000 acre-feet New irrigation yield: 48,000 acre-feet

Season	Water supply			Distribution of water supply					Seasonal irrigation deficiency, in per cent of new irrigation demand
	Storage, October 1	Inflow to reservoir	Evapor-ation	New irrigation release	Release for historic retention	Total release	Spill	Storage, September 30	
1920-21	0	209,600	7,400	45,100	48,400	93,500	0	108,700	6.0
21-22	108,700	208,300	11,500	48,000	45,000	93,000	35,300	177,200	0
22-23	177,200	171,300	11,600	48,000	48,100	96,100	42,600	198,200	0
23-24	198,200	22,700	9,900	48,000	24,500	72,500	0	138,500	0
24-25	138,500	150,700	10,900	48,000	47,600	95,600	17,800	164,900	0
1925-26	164,900	62,100	9,900	48,000	44,600	92,600	0	124,500	0
26-27	124,500	171,300	10,700	48,000	47,900	95,900	18,600	170,600	0
27-28	170,600	123,600	10,700	48,000	48,200	96,200	30,900	156,400	0
28-29	156,400	39,100	9,000	48,000	34,700	82,700	0	103,800	0
29-30	103,800	62,900	8,200	48,000	34,900	82,900	0	75,600	0
1930-31	75,600	13,100	4,900	48,000	11,600	59,600	0	24,200	0
31-32	24,200	129,800	7,400	48,000	41,100	89,100	0	57,500	0
32-33	57,500	31,300	4,900	48,000	23,000	71,000	0	12,900	0
33-34	12,900	52,300	3,300	34,600	27,100	61,700	0	200	27.9
34-35	200	143,700	6,000	45,100	46,100	91,200	0	46,700	6.0

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, COMBINED OPERATION OF MELONES, TULLOCH, AND WOODWARD RESERVOIRS

(In acre-feet)

Storage capacity: 216,900 acre-feet Irrigation yield: 400,000 acre-feet

Season	Water supply		Distribution of water supply					Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Storable inflow to reservoir (combined)	Evaporation	Fish release	Irrigation release	Spill	Storage, September 30	
1920-21	0	1,122,400	16,100	30,900	375,500	590,600	84,800	0
21-22	84,800	1,352,400	18,200	30,900	400,000	865,900	122,200	0
22-23	122,200	1,026,400	17,500	30,900	400,000	598,900	101,300	0
23-24	101,300	299,800	16,800	30,900	337,900	0	15,500	15.5
24-25	15,500	1,028,900	16,800	30,900	394,000	519,800	82,900	1.5
1925-26	82,900	567,300	14,000	30,900	400,000	165,300	40,000	0
26-27	40,000	1,227,400	16,800	30,900	400,000	718,200	101,500	0
27-28	101,500	879,100	14,700	30,900	400,000	490,600	44,400	0
28-29	44,400	474,200	14,000	30,900	400,000	8,100	65,600	0
29-30	65,600	616,200	14,000	30,900	400,000	169,600	67,300	0
1930-31	67,300	314,900	9,100	30,900	326,700	0	15,500	18.4
31-32	15,500	1,248,200	18,200	30,900	394,800	701,700	118,100	1.3
32-33	118,100	546,300	15,400	30,900	400,000	156,500	61,600	0
33-34	61,600	420,200	14,000	30,900	382,400	39,000	15,500	4.4
34-35	15,500	1,106,800	16,800	30,900	400,000	585,600	89,000	0

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, NEW MELONES RESERVOIR ON STANISLAUS RIVER *

(In acre-feet)

Storage capacity: 1,100,000 acre-feet

New irrigation yield: 300,000 acre-feet

Season	Water supply		Distribution of water supply				Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Storable inflow	Evaporation	New water irrigation release	Spill	Storage, September 30	
1920-21	0	615,100	8,100	300,000	0	323,000	0
21-22	323,000	865,900	14,100	300,000	0	874,800	0
22-23	874,900	598,900	18,000	300,000	223,300	932,600	0
23-24	932,600	0	15,000	300,000	0	617,600	0
24-25	617,600	519,800	15,000	300,000	0	822,400	0
1925-26	822,400	165,300	15,000	300,000	0	672,700	0
26-27	672,700	718,200	16,600	300,000	140,300	934,000	0
27-28	934,000	490,600	15,000	300,000	310,900	798,700	0
28-29	798,700	8,100	14,000	300,000	0	492,800	0
29-30	492,800	169,600	13,700	300,000	0	348,700	0
1930-31	348,700	0	8,000	230,700	0	110,000	23.1
31-32	110,000	701,700	10,000	284,000	0	517,700	5.3
32-33	517,700	156,500	9,400	300,000	0	364,800	0
33-34	364,800	39,000	8,000	285,800	0	110,000	4.7
34-35	110,000	585,600	8,000	284,000	0	403,600	5.3

* Storable inflow to New Melones consists of spill from the combined operation of Melones, Tulloch, and Woodward Reservoirs.

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, MELONES RESERVOIR ON STANISLAUS RIVER COMBINED WITH WOODWARD RESERVOIR ON SIMMONS CREEK

(In acre-feet)

Combined gross storage capacity: 147,500 acre-feet

Irrigation yield: 270,000 acre-feet

Season	Water supply		Distribution of water supply					Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Storable inflow to reservoir (combined)	Evaporation	Fish release	Irrigation release	Spill	Storage, September 30	
1920-21	0	1,151,900	7,300	30,900	252,800	779,500	81,400	6
21-22	81,400	1,350,700	8,100	30,900	270,000	1,026,100	97,000	0
22-23	97,000	1,034,800	8,200	30,900	270,000	726,700	96,000	0
23-24	96,000	202,700	6,400	30,900	245,800	6,100	9,500	9
24-25	9,500	1,115,300	7,300	30,900	258,600	747,600	80,400	4
1925-26	80,400	527,500	7,100	30,900	270,000	279,600	20,300	0
26-27	20,300	1,264,700	7,500	30,900	270,000	880,600	96,000	0
27-28	96,000	866,800	7,400	30,900	270,000	607,600	46,900	0
28-29	46,900	452,300	7,000	30,900	270,000	141,000	50,300	0
29-30	50,300	645,600	7,200	30,900	270,000	328,200	59,600	0
1930-31	59,600	252,300	6,600	30,900	260,400	4,500	9,500	4
31-32	9,500	1,306,800	7,500	30,900	256,700	928,000	93,200	5
32-33	93,200	549,100	7,600	30,900	270,000	277,000	56,800	0
33-34	56,800	367,500	6,900	30,900	270,000	95,200	21,300	0
34-35	21,300	1,159,800	7,500	30,900	270,000	785,900	86,800	0

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, NEW MELONES RESERVOIR ON STANISLAUS RIVER COMBINED WITH WOODWARD RESERVOIR ON SIMMONS CREEK

(In acre-feet)

Combined gross starage capacity: 1,135,500 acre-feet

Irrigation yield: 710,000 acre-feet

Season	Water supply		Distribution of water supply					Seasonal irrigation deficiency, in per cent of irrigation demand
	Storage, October 1	Storable inflow to reservoir (combined)	Evaporation	Fish release	Irrigation release	Spill	Storage, September 30	
1920-21	0	1,151,900	16,500	30,900	671,400	0	433,100	5.4
21-22	433,100	1,350,700	26,100	30,900	710,000	122,800	894,000	0
22-23	894,000	1,034,800	29,800	30,900	710,000	278,300	879,800	0
23-24	879,800	202,700	22,900	30,900	710,000	0	318,700	0
24-25	318,700	1,115,300	23,600	30,900	710,000	0	669,500	0
1925-26	669,500	527,500	24,300	30,900	710,000	0	431,800	0
26-27	431,800	1,264,700	26,800	30,900	710,000	60,000	868,800	0
27-28	868,800	866,800	26,500	30,900	710,000	231,900	736,300	0
28-29	736,300	452,300	23,700	30,900	710,000	0	424,000	0
29-30	424,000	645,600	22,200	30,900	710,000	0	306,500	0
1930-31	306,500	252,300	9,100	30,900	498,800	0	20,000	29.7
31-32	20,000	1,306,800	17,700	30,900	675,500	0	602,700	4.9
32-33	602,700	549,100	21,400	30,900	710,000	0	389,500	0
33-34	389,500	367,500	13,800	30,900	692,300	0	20,000	2.5
34-35	20,000	1,159,800	16,400	30,900	678,900	0	453,600	4.4
1935-36	453,600	1,317,700	27,200	30,900	710,000	145,300	857,900	0

APPENDIX L

ESTIMATES OF COST

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ESTIMATED COST OF DELTA-MOKELUMNE RIVER DIVERSION PROJECT

Delta Diversion

(Based on prices prevailing in April, 1953)

Pumping plant capacity: 250 second-feet
Gross seasonal diversion: 60,000 acre-feet

Maximum monthly demand: 13,200 acre-feet
Acreage served: 17,500 acres

Item	Quantity	Unit price	Cost	
Capital Costs				
Pumping Plant				
Pumps, motors, controls		lump sum	$111,300	
Structural concrete	354 cu.yd.	$100.00	35,400	
Reinforcing steel	46,000 lbs.	0.15	6,900	
Welded steel pipe	26,210 lbs.	0.30	7,900	
Pipe (specials)	1,160 lb.	0.50	600	
Flap valves				
30″ diameter	5	120.00	600	
24″ diameter	1	80.00	100	
Trash rack steel	1,800 lb.	0.25	500	
Treated wood piling	3,700 lin.ft.	4.50	15,200	$178,500
Subtotal				$178,500
Administration and engineering, 10%				$17,900
Contingencies, 15%				26,800
Interest during construction, none				
Total, pumping plant				$223,200
Conveyance System				
Excavation and haul	500,000 cu.yd.	$0.40	$200,000	
Compacted fill	430,000 cu.yd.	0.50	215,000	
Trimming	50,700 sq.yd.	0.50	25,400	
Concrete canal lining	50,700 sq.yd.	3.50	177,400	
Dredging existing slough	12,600 cu.yd.	0.50	6,300	
Highway, railroad, and canal crossings		lump sum	57,900	
Rights of way		lump sum	46,000	$728,000
Subtotal				$728,000

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Conveyance System—Continued			
Administration and engineering, 10%			$72,800
Contingencies, 15%			109,200
Interest during construction, none			
Total conveyance system			$910,000
TOTAL			$1,133,200
Annual Costs			
Pumping Plant			
Interest, 3%			$6,700
Repayment, 0.887%			2,000
Replacement, 1.20%			2,700
Operation and maintenance			9,000
Electric energy			41,600
Total, pumping plant			$62,000
Conveyance System			
Interest, 3%			$27,800
Repayment, 0.887%			8,100
Replacement, 0.02%			200
Operation and maintenance, 0.5%			4,500
Total, conveyance system			$40,100
TOTAL			$102,100

ESTIMATED COST OF DELTA-MOKELUMNE RIVER DIVERSION PROJECT—Continued
Clements Diversion With 125 Second-foot Capacity

(Based on prices prevailing in April, 1953)

Pumping plant capacity: 125 second-feet
Gross seasonal diversion: 30,000 acre-feet
Maximum monthly demand: 6,600 acre-feet
Acreage served: 7,500 acres

Item	Quantity	Unit price	Cost	
Capital Costs				
Pumping Plant				
Pumps, motor, and electrical equipment	3 ea.	$30,500	$91,500	
Sump and trashrack		lump sum	5,100	
Protective housing, foundation, and pump supports		lump sum	6,000	
Discharge structure and sand trap		lump sum	7,400	
Structural excavation	1,090 cu.yd.	3.00	3,300	
Backfill	80 cu.yd.	1.50	100	
Riprap	220 cu.yd.	8.00	1,800	$115,200
Subtotal				$115,200
Administration and engineering, 10%				$11,500
Contingencies, 15%				17,300
Interest during construction, none				
Total, pumping plant				$144,000
Conveyance System				
Excavation	18,000 cu.yd.	$0.30	$5,400	
Compacted fill	4,300 cu.yd.	0.50	2,200	
Trimming	3,900 sq.yd.	0.75	2,900	
Concrete lining	3,900 sq.yd.	3.50	13,600	
Crossing				
State Highway 12		lump sum	13,000	
Railroad		lump sum	6,000	
Outlet structure		lump sum	3,200	
Rights of way		lump sum	3,200	$49,500
Subtotal				$49,500

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Conveyance System—Continued			
Administration and engineering, 10%			$5,000
Contingencies, 15%			7,400
Interest during construction, none			
Total, conveyance system			$61,900
TOTAL			$205,900
Annual Costs			
Pumping Plant			
Interest, 3%			$4,300
Repayment, 0.887%			1,300
Replacement, 1.2%			1,700
Operation and maintenance			2,500
Electric energy			33,100
Insurance, 0.12%			200
Total, pumping plant			$43,100
Conveyance System			
Interest, 3%			$1,900
Repayment, 0.887%			600
Replacement, 0.07%			100
Operation and maintenance, 0.5%			300
Total, conveyance system			$2,900
TOTAL			$46,000

ESTIMATED COST OF DELTA-MOKELUMNE RIVER DIVERSION PROJECT—Continued
Lockeford Diversion With 125 Second-foot Capacity

(Based on prices prevailing in April, 1953)

Pumping plant capacity: 125 second-feet
Gross seasonal diversion: 30,000 acre-feet

Maximum monthly demand: 6,600 acre-feet
Acreage served: 10,000 acres

Item	Quantity	Unit price	Cost	
Capital Costs				
Pumping Plant				
Pumps, motors, and electrical equipment	3 ea.	$18,800	$56,400	
Sump and trash rack		lump sum	5,100	
Protective housing, foundation, and pump supports		lump sum	6,000	
Discharge structure and sand trap		lump sum	7,400	
Structural excavation	1,090 cu.yd.	3.00	3,300	
Backfill	80 cu.yd.	1.50	100	
Riprap	120 cu.yd.	8.00	1,000	$79,300
Subtotal				$79,300
Administration and engineering, 10%				$7,900
Contingencies, 15%				11,900
Interest during construction, none				
Total, pumping plant				$99,100
Conveyance System				
Excavation	33,500 cu.yd.	$0.30	$10,100	
Compacted fill	15,500 cu.yd.	0.50	7,700	
Trimming	47,800 sq.yd.	0.75	35,900	
Concrete lining	47,800 sq.yd.	3.50	167,300	
Timber bridges	5 ea.	6,500	32,500	
Headgate structure		lump sum	3,200	
Rights of way		lump sum	19,900	$276,600
Subtotal				$276,600

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Conveyance System—Continued			
Administration and engineering, 10%			$27,700
Contingencies, 15%			41,500
Interest during construction, none			
Total, conveyance system			$345,800
TOTAL			$444,900
Annual Costs			
Pumping Plant			
Interest, 3%			$3,000
Repayment, 0.887%			900
Replacement, 1.2%			1,200
Insurance, 0.12%			100
Operation and maintenance			3,500
Electric energy			19,000
Total, pumping plant			$27,700
Conveyance System			
Interest, 3%			$10,400
Repayment, 0.887%			3,100
Replacement, 0.02%			200
Operation and maintenance, 0.5%			1,700
Total, conveyance system			$15,400
TOTAL			$43,100

ESTIMATED COST OF MEHRTEN PROJECT

Mehrten Dam and Reservoir

(Based on prices prevailing in April, 1953)

Elevation of crest of dam: 170 feet, U. S. G. S. datum
Elevation of crest of spillway: 152 feet
Height of dam to spillway crest, above stream bed: 67 feet

Capacity of reservoir to crest of spillway: 50,000 acre-feet
Capacity of spillway with 5-foot freeboard: 100,000 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Dam				
Diversion and care of stream		lump sum	$100,000	
Exploration of dam site		lump sum	100,000	
Stripping and preparation of foundation	103,500 cu.yd.	$0.85	88,000	
Embankment				
Impervious (salvage)	230,100 cu.yd.	0.35	80,500	
Random (salvage)	188,100 cu.yd.	0.35	65,800	
Pervious	115,000 cu.yd.	0.45	51,800	
Riprap	36,500 cu.yd.	1.50	54,800	
Relief wells	16 ea.	1,300	20,800	$561,700
Auxiliary Dams				
Stripping and preparation of foundation	19,950 cu.yd.	1.00	20,000	
Embankment				
Impervious	18,400 cu.yd.	0.70	12,900	
Pervious	28,100 cu.yd.	0.65	18,300	
Riprap	8,000 cu.yd.	1.50	12,000	63,200
Spillway				
Excavation	490,100 cu.yd.	1.00	490,100	
Concrete	10,220 cu.yd.	35.00	357,700	
Reinforcing steel	760,000 lb.	0.15	114,000	961,800
Outlet Works				
Excavation	12,400 cu.yd.	2.00	24,800	
Concrete				
Pipe encasement	825 cu.yd.	30.00	24,800	
Structural	205 cu.yd.	100.00	20,500	
Steel pipe 8′ diameter	108,000 lb.	0.25	27,000	
Capital Costs—Continued				
Outlet Works—Continued				
Trash rack steel	37,700 lb.	$0.25	$9,400	
Piling	1,410 lin. ft.	4.50	6,300	
High-pressure slide gates, 5′ x 5′	4 ea.	24,000	96,000	
Valves housing access		lump sum	2,000	$210,800
Reservoir				
Land and improvements		lump sum	864,800	
Public utilities		lump sum	246,000	
Clearing	1,000 ac.	50.00	50,000	1,160,800
Subtotal				$2,958,300
Administration and engineering, 10%				$295,800
Contingencies, 15%				443,700
Interest during construction, none				
TOTAL				$3,697,800
Annual Costs				
Interest, 3%				$110,900
Repayment, 0.887%				32,800
Replacement, 0.07%				2,600
Operation and maintenance				7,500
TOTAL				$153,800

ESTIMATED COST OF MEHRTEN PROJECT—Continued
Clements Diversion With 25 Second-foot Capacity

(Based on prices prevailing in April, 1953)

Pumping plant capacity: 25 second-feet
Gross seasonal diversion: 6,850 acre-feet
Maximum monthly demand: 1,500 acre-feet
Acreage served: 1,700 acres

Item	Quantity	Unit price	Cost	
Capital Costs				
Pumping Plant				
Pumps, motor, and electrical equipment	2 ea.	$8,300	$16,600	
Sump and trash rack		lump sum	3,100	
Protective housing, foundation and pump supports		lump sum	4,100	
Discharge structure and sand trap		lump sum	1,800	
Structural excavation	485 cu.yd.	3.00	1,500	
Backfill	30 cu.yd.	1.50	100	
Riprap	200 cu.yd.	8.00	1,600	$28,800
Subtotal				$28,800
Administration and engineering, 10%				$2,900
Contingencies, 15%				4,300
Interest during construction, none				
Total, pumping plant				$36,000
Conveyance system				
Excavation	18,400 cu.yd.	0.30	5,500	
Compacting fill	2,400 cu.yd.	0.50	1,200	
Trimming	1,970 sq.yd.	0.75	1,500	
Shotcrete lining	1,970 sq.yd.	3.50	6,900	
Crossings				
State Highway 12		lump sum	12,000	
Railroad		lump sum	6,000	
Outlet structure		lump sum	1,400	
Rights of way		lump sum	3,200	$37,700
Subtotal				$37,700

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Conveyance System—Continued			
Administration and engineering, 10%			$3,800
Contingencies, 15%			5,700
Interest during construction, none			
Total, conveyance system			$47,200
TOTAL			$83,200
Annual Costs			
Pumping Plant			
Interest, 3%			$1,100
Repayment, 0.887%			300
Replacement, 1.2%			500
Operation and maintenance			1,500
Electric energy			6,400
Insurance, 0.12%			100
Total, pumping plant			$9,900
Conveyance System			
Interest, 3%			$1,400
Repayment, 0.887%			400
Replacement, 0.02% (negligible)			
Operation and maintenance, 1.0%			500
Total, conveyance system			$2,300
TOTAL			$12,200

ESTIMATED COST OF MEHRTEN PROJECT—Continud
Lockeford Diversion With 25 Second-foot Capacity

(Based on prices prevailing in April, 1953)

Pumping plant capacity: 25 second-feet
Gross seasonal diversion: 6,850 acre-feet

Maximum monthly demand: 1,500 acre-feet
Acreage served: 2,300 acres

Item	Quantity	Unit price	Cost	
Capital Costs				
Pumping Plant				
Pumps, motors, and electrical equipment	2 ea.	$7,250	$14,500	
Sump and trash rack		lump sum	3,100	
Protective housing, foundation, and pump supports		lump sum	4,100	
Discharge structure and sand trap		lump sum	1,800	
Structural excavation	485 cu.yd.	3.00	1,500	
Backfill	30 cu.yd.	1.50	100	
Riprap	100 cu.yd.	8.00	800	$25,900
Subtotal				$25,900
Administration and engineering, 10%				$2,600
Contingencies, 15%				3,900
Interest during construction, none				
Total, pumping plant				$32,400
Conveyance System				
Excavation	13,400 cu.yd.	0.30	4,000	
Compacted fill	13,400 cu.yd.	0.50	6,700	
Trimming	26,600 sq.yd.	0.75	20,000	
Shotcrete lining	26,600 sq.yd.	3.50	93,200	
Timber bridges	5 ea.	3,540	17,700	
Headgate structure		lump sum	1,400	
Rights of way		lump sum	12,400	$155,400
Subtotal				$155,400

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Conveyance System—Continued			
Administration and engineering, 10%			$15,500
Contingencies, 15%			23,300
Interest during construction, none			
Total, conveyance system			$194,200
TOTAL			$226,600
Annual Costs			
Pumping Plant			
Interest, 3%			$1,000
Repayment, 0.887%			300
Replacement, 1.2%			400
Insurance, 0.12%			100
Operation and maintenance			1,600
Electric energy			4,700
Total, pumping plant			$8,100
Conveyance System			
Interest, 3%			$5,800
Repayment, 0.887%			1,700
Replacement, 0.07%			100
Operation and maintenance, 0.5%			1,000
Total, conveyance system			$8,600
TOTAL			$16,700

ESTIMATED COST OF CAMANCHE PROJECT

Camanche Dam and Reservoir

(Based on prices prevailing in April, 1953)

Elevation of crest of dam: 220 feet, U. S. G. S. datum
Elevation of crest of spillway: 202 feet
Height of dam to spillway crest, above stream bed: 112 feet
Capacity of reservoir to crest of spillway: 212,000 acre-feet
Capacity of spillway with 5-foot freeboard: 77,000 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Dam				
Diversion and care of stream		lump sum	$100,000	
Exploration of dam site		lump sum	100,000	
Stripping and preparation of foundation	649,000 cu.yd.	$0.85	589,900	
Embankment				
Impervious	1,472,000 cu.yd.	0.70	1,030,400	
Pervious (tailings)	580,000 cu.yd.	0.45	261,000	
Random (salvage)	1,028,000 cu.yd.	0.35	351,800	
Riprap	172,000 cu.yd.	1.50	258,000	
Relief wells	22 ea.	1,300	28,600	$2,719,700
Auxiliary Dams				
Stripping and preparation of foundation	364,000 cu.yd.	1.00	364,000	
Embankment	1,260,000 cu.yd.	0.70	882,000	
Riprap	210,000 cu.yd.	1.50	315,000	1,561,000
Spillway				
Excavation	1,319,000 cu.yd.	0.75	989,300	
Concrete	15,150 cu.yd.	35.00	530,300	
Reinforcing steel	1,135,000 lb.	0.15	170,300	
Tainter gate and hoist		lump sum	68,000	1,757,900
Outlet Works				
Excavation	9,400 cu.yd.	2.00	18,800	
Concrete	5,500 cu.yd.	40.00	220,000	
Reinforcing steel	180,000 lb.	0.15	27,000	
Steel pipe	62,800 lb.	0.20	12,600	
Capital Costs Continued				
Outlet Works—Continued				
High-pressure slide gates, 6′ x 6′		lump sum	$124,800	
Howell-Bunger valve, 78″ diameter		lump sum	36,000	
Trash rack steel	9,400 lb.	$0.25	2,400	$441,600
Reservoir				
Land and improvements		lump sum	1,403,000	
Public utilities		lump sum	521,000	
Clearing	8,000 ac.	50.00	400,000	2,324,000
Subtotal				$8,804,200
Engineering and administration, 10%				$880,400
Contingencies, 15%				1,326,600
Interest during construction				165,200
TOTAL				$11,176,400
Annual Costs				
Interest, 3%				$335,300
Repayment, 0.887%				99,100
Replacement, 0.07%				7,800
Operation and maintenance				19,200
TOTAL				$461,400

ESTIMATED COST OF CAMANCHE PROJECT—Continued

Camanche Power Plant

(Based on prices prevailing in April, 1953)

Capacity of power plant: 4,000 kilowatts
Location: 100 feet downstream from dam
Maximum head: 100 feet
Length of penstock: 380 feet
Diameter of penstock: 7 feet
Capacity of penstock: 600 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Power plant		lump sum	$660,000	
Penstock	380 lin.ft.	$80.00	30,400	$690,400
Subtotal				$690,400
Administration and engineering, 10%				$66,000
Contingencies, 15%				103,600
Interest during construction				12,400
TOTAL				$872,400
Annual Costs				
Interest, 3%				$26,200
Repayment, 0.887%				7,700
Replacement, 1.20%				10,500
Insurance, 0.12%				1,100
Operation and maintenance				35,000
TOTAL				$80,500

ESTIMATED COST OF MIDDLE BAR PROJECT

Middle Bar Dam and Reservoir

(Based on prices prevailing in April, 1953)

Elevation of crest of dam: 695 feet, U. S. G. S. datum
Elevation of crest of gates: 690 feet
Height of dam to spillway crest above stream bed: 155 feet

Capacity of reservoir to crest of gates: 46,500 acre-feet
Capacity of spillway with 5-foot freeboard: 87,000 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Dam				
Diversion and care of stream		lump sum	$300,000	
Stripping and preparation of foundation	46,100 cu.yd.	$5.00	230,500	
Concrete				
Mass	127,950 cu.yd.	14.00	1,791,300	
Reinforced				
Parapet and training walls	442 cu.yd.	40.00	17,700	
Trash rack and bridge	325 cu.yd.	100.00	32,500	$2,372,000
Outlet Works				
Steel pipe, 5′ diameter	23,500 lb.	0.25	5,900	
Slide gates, 4½′ x 4½′	4 ea.	23,400	93,600	
Reinforcing steel	82,400 lb.	0.15	12,400	
Trash rack steel	146,300 lb.	0.25	36,600	
Miscellaneous metal	96,700 lb.	0.25	24,200	
Drilling grout holes	3,600 lin.ft.	4.00	14,400	
Pressure grouting	2,700 cu.ft.	4.00	10,800	
Broome gate, 18′ x 18′, and hoist	1 ea.	85,000	85,000	
Tainter gates, 30′ x 50′, and hoists	3 ea.	34,700	104,100	387,000

Item	Quantity	Unit price	Cost	
Capital Costs—Continued				
Reservoir				
Land and improvements		lump sum	$200,000	
Public utilities		lump sum	668,000	
Clearing	800 ac.	$200.00	160,000	$1,028,000
Subtotal				$3,787,000
Administration and engineering, 10%				$378,700
Contingencies, 15%				568,100
Interest during construction				142,000
TOTAL				$4,875,800
Annual Costs				
Interest, 3%				$146,300
Repayment, 0.887%				43,200
Replacement, 0.07%				3,400
Operation and maintenance				7,200
TOTAL				$200,100

ESTIMATED COST OF MIDDLE BAR PROJECT—Continued

Middle Bar Power Plant

(Based on prices prevailing in April, 1953)

Capacity of power plant: 10,000 kilowatts
Location: Immediately downstream from dam
Maximum head: 115 feet

Length of penstock: 300 feet
Diameter of penstock: 12 feet
Capacity of penstock: 1,300 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Penstock	300 lin.ft.	$185.00	$55,500	
Power plant, 10,000 kw.		lump sum	1,350,000	$1,405,500
Subtotal				$1,405,500
Administration and engineering, 10%				$140,600
Contingencies, 15%				210,800
Interest during construction				52,700
TOTAL				$1,809,600

Item	Quantity	Unit price	Cost
Annual Costs			
Interest, 3%			$54,300
Repayment, 0.887%			16,100
Replacement, 1.20%			21,700
Insurance, 0.12%			2,200
Operation and maintenance			57,000
TOTAL			$151,300

ESTIMATED COST OF RAILROAD FLAT PROJECT
Railroad Flat Dam and Reservoir

(Based on prices prevailing in April, 1953)

Elevation of crest of dam: 2,469 feet, U. S. G. S. datum
Elevation of crest of spillway: 2,459 feet
Height of dam to spillway crest, above stream bed: 329 feet
Capacity of reservoir to crest of spillway: 80,000 acre-feet
Capacity of spillway with 4-foot freeboard: 12,000 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Dam				
Diversion and care of stream		lump sum	$40,000	
Stripping and preparation of foundation	250,200 cu.yd.	$1.50	375,300	
Special foundation treatment		lump sum	500,000	
Embankment				
Impervious	1,438,900 cu.yd.	1.15	1,654,700	
Pervious	3,227,700 cu.yd.	1.80	5,809,900	
Drilling grout holes	7,800 lin.ft.	4.00	31,200	
Pressure grouting	5,200 cu.ft.	4.00	20,800	$8,431,900
Spillway				
Excavation	397,100 cu.yd.	2.00	794,200	
Concrete	3,050 cu.yd.	35.00	106,800	
Reinforcing steel	228,000 lb.	0.15	34,200	935,200
Outlet works				
Excavation	4,800 cu.yd.	2.00	9,600	
Concrete, structural	50 cu.yd.	100.00	5,000	
Tunnel, 8′ diameter	2,450 lin.ft.	230.00	563,500	
Steel pipe, 48″ diameter	111,000 lb.	0.25	27,800	
High-pressure slide gate, 3½′ x 3½′		lump sum	22,800	
Howell-Bunger valve, 48″ diameter		lump sum	14,400	
Capital Costs—Continued				
Outlet Works—Continued				
Trash rack		lump sum	$1,000	
Reinforcing steel	8,000 lb.	0.15	1,200	$645,300
Reservoir				
Land		lump sum	73,400	
Public utilities		lump sum	199,000	
Clearing	678 ac.	250.00	169,500	441,900
Subtotal				$10,454,300
Administration and engineering, 10%				$1,045,400
Contingencies, 15%				1,568,100
Interest during construction				588,100
TOTAL				$13,655,900
Annual Costs				
Interest, 3%				$409,700
Repayment, 0.887%				121,100
Replacement, 0.07%				9,600
Operation and maintenance				10,500
TOTAL				$550,900

ESTIMATED COST OF RAILROAD FLAT PROJECT—Continued
Middle Fork Diversion

(Based on prices prevailing in April, 1953)

Elevation of crest of weir: 2,750 feet
Height of weir above stream bed: 10 feet
Capacity of diversion conduit: 100 second-feet
Length of conduit: Lined canal, 2.1 miles

Item	Quantity	Unit price	Cost	
Capital Costs				
Diversion Works				
Mass concrete	467 cu.yd.	$30.00	$14,000	
Structural concrete	280 cu.yd.	100.00	28,000	
Reinforcing steel	56,000 lb.	0.15	8,400	
Trash rack steel	10,400 lb.	0.25	2,600	
Sluice gates, 4′ diameter	2 ea.	800.00	1,600	
Headgates, 4′ x 5′	3 ea.	1,000	3,000	
Excavation, structural	550 cu.yd.	3.00	1,600	$59,200
Subtotal				$59,200
Administration and engineering, 10%				$5,900
Contingencies, 15%				8,900
Interest during construction, none				
Total, diversion works				$74,000
Canal				
Excavation	21,600 cu.yd.	0.40	8,600	
Compacted fill	16,600 cu.yd.	0.50	8,300	
Trimming	13,150 sq.yd.	0.75	9,900	
Shotcrete lining	13,150 sq.yd.	4.00	52,600	
Road crossing		lump sum	3,500	
Rights of way		lump sum	1,200	$84,100
Subtotal				$84,100
Capital Costs—Continued				
Administration and engineering, 10%				$8,400
Contingencies, 15%				12,600
Interest during construction, none				
Total, canal				$105,100
TOTAL				$179,100
Annual Costs				
Interest, 3%				$5,400
Repayment, 0.887%				1,600
Replacement, 0.07%				100
Operation and maintenance, 0.5%				900
TOTAL				$8,000

ESTIMATED COST OF IONE PROJECT
Ione Dam and Reservoir

(Based on prices prevailing in April, 1953)

Elevation of crest of dam: 215 feet, U. S. G. S. datum
Elevation of crest of spillway: 200 feet
Height of dam to crest of spillway, above stream bed: 40 feet

Capacity of reservoir to crest of spillway: 40,000 acre-feet
Capacity of spillway with 5-foot freeboard: 42,000 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Dam				
Unwatering dam site		lump sum	$10,000	
Stripping and preparation of foundation	182,400 cu.yd.	$0.85	155,000	
Embankment				
Impervious	276,000 cu.yd.	0.65	179,500	
Pervious	322,200 cu.yd.	0.50	161,100	$505,600
Spillway				
Excavation	70,900 cu.yd.	1.00	70,900	
Concrete	4,720 cu.yd.	35.00	165,200	
Reinforcing steel	362,500 lb.	0.15	54,400	290,500
Outlet Works				
Excavation	1,460 cu.yd.	2.00	2,900	
Conercte				
Pipe encasement	305 cu.yd.	30.00	9,100	
Structural	66 cu.yd.	100.00	6,600	
Steel pipe, 48″ diameter	45,000 lb.	0.25	11,200	
Reinforcing steel	45,600 lb.	0.15	6,800	
Trash rack steel	3,200 lb.	0.25	800	
Slide gate, 4′ x 4′, and hoist		lump sum	5,000	
Howell-Bunger valve, 36″ diameter		lump sum	7,600	
Stilling basin		lump sum	1,000	51,000

Item	Quantity	Unit price	Cost	
Capital Costs—Continued				
Reservoir				
Land and improvements		lump sum	$618,000	
Public utilities		lump sum	237,500	
Clearing	100 ac.	100.00	10,000	$865,500
Subtotal				$1,712,600
Administration and engineering, 10%				$171,300
Contingencies, 15%				257,000
Interest during construction				64,200
TOTAL				$2,205,000
Annual Costs				
Interest, 3%				$66,200
Repayment, 0.887%				19,600
Replacement, 0.07%				1,500
Operation and maintenance				6,500
TOTAL				$93,800

ESTIMATED COST OF IONE PROJECT—Continued
Dry Creek-Clements Conduit

(Based on prices prevailing in April, 1953)

Elevation of outlet at Ione Reservoir: 165 feet, U. S. G. S. datum
Elevation at terminus of conduit: 129 feet
Capacity of diversion conduit: 85 second-feet

Length of conduit
Lined canal: 7.7 miles
Unlined canal: 4.5 miles
Goose Creek Siphon: 1,900 feet
Coyote Creek Siphon: 370 feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Conduit				
Canal				
Excavation	18,700 cu.yd.	$0.30	$5,600	
Compaction	65,000 cu.yd.	0.50	32,500	
Trimming	90,500 sq.yd.	0.50	45,300	
Concrete lining	90,500 sq.yd.	3.50	316,800	
Goose Creek Siphon	1,900 lin.ft.	20.00	38,000	
Coyote Creek Siphon	370 lin.ft.	20.00	7,400	
Transitions	4 ea.	250.00	1,000	
Road crossings	3 ea.	4,500	13,500	
Farm bridges	12 ea.	3,000	36,000	
Rights of way		lump sum	15,000	$511,100
Subtotal				$511,100

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Administration and engineering, 10%			$51,100
Contingencies, 15%			76,700
Interest during construction, none			
TOTAL			$638,900
Annual Costs			
Interest, 3%			$19,200
Repayment, 0.887%			5,700
Replacement, 0.05%			200
Operation and maintenance			3,200
TOTAL			$28,300

ESTIMATED COST OF IRISH HILL PROJECT

Irish Hill Dam and Reservoir

(Based on prices prevailing in April, 1953)

Elevation of crest of dam: 550 feet, U. S. G. S. datum
Elevation of crest of spillway: 536 feet
Height of dam to spillway crest, above stream bed: 136 feet
Capacity of reservoir to crest of spillway: 43,500 acre-feet
Capacity of spillway with 4-foot freeboard: 22,000 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Dam				
Diversion and care of stream		lump sum	$15,000	
Stripping and preparation of foundation	120,500 cu.yd.	$1.50	180,800	
Embankment				
Impervious	249,500 cu.yd.	0.90	224,600	
Pervious	530,900 cu.yd.	0.70	371,600	
Drilling grout holes	1,040 lin.ft.	4.00	4,200	
Pressure grouting	1,660 cu.ft.	4.00	6,600	$802,800
Auxiliary Dam				
Stripping and preparation of foundation	12,200 cu.yd.	1.50	18,300	
Embankment	34,300 cu.yd.	0.90	30,900	
Riprap	5,200 cu.yd.	3.00	15,600	64,800
Spillway				
Excavation	47,400 cu.yd.	1.50	71,100	
Concrete	4,080 cu.yd.	35.00	142,800	
Reinforcing steel	308,000 lb.	0.15	46,200	260,100
Outlet Works				
Excavation	1,040 cu.yd.	3.00	3,100	
Concrete				
Pipe encasement	370 cu.yd.	30.00	11,100	
Structural	50 cu.yd.	90.00	4,500	
Steel pipe, 48″ diameter	102,600 lb.	0.25	25,700	
Reinforcing steel	47,000 lb.	0.15	7,100	
Butterfly valves, 36″ diameter	2 ea.	5,000	10,000	

Item	Quantity	Unit price	Cost	
Capital Costs—Continued				
Outlet Works—Continued				
Howell-Bunger valve, 48″ diameter	1 ea.	$22,000	$22,000	
Trash rack		lump sum	3,000	$87,000
Reservoir				
Land and improvements		lump sum	225,500	
Utilities		lump sum	135,000	
Clearing	1,350 ac.	75.00	101,300	461,800
Subtotal				$1,676,500
Administration and engineering, 10%				$167,700
Contingencies, 15%				251,500
Interest during construction				62,900
TOTAL				$2,158,600
Annual Costs				
Interest, 3%				$64,800
Repayment, 0.887%				19,100
Replacement, 0.07%				1,500
Operation and maintenance				6,900
TOTAL				$92,300

ESTIMATED COST OF IRISH HILL PROJECT—Continued

Sutter Creek Diversion

(Based on prices prevailing in April, 1953)

Elevation of crest of weir: 1,077 feet, U. S. G. S. datum
Height of weir crest, above stream bed: 6 feet
Length of weir: 100 feet
Capacity of weir with 9.5-foot head: 10,000 second-feet
Capacity of conduit: 200 second-feet
Total length of conduit: 2.9 miles

Item	Quantity	Unit price	Cost	
Capital Costs				
Diversion Works				
Excavation	550 cu.yd.	$3.00	$1,700	
Concrete				
Weir	450 cu.yd.	30.00	13,500	
Structural	14 cu.yd.	100.00	1,400	
Reinforcing steel	14,000 lb.	0.15	2,100	
Headgate and sluice gates		lump sum	1,000	
Trash rack		lump sum	800	$20,500
Conduit				
Flume	8,400 lin.ft.	30.00	252,000	
Siphons	2 ea.	lump sum	50,000	
Canal				
Excavation	27,500 cu.yd.	1.50	41,200	
Trimming	14,400 sq.yd.	0.75	10,800	
Shotcrete lining	14,400 sq.yd.	3.50	50,400	
Road crossing		lump sum	2,000	
Rights of way		lump sum	1,200	
Access road		lump sum	2,000	409,600
Subtotal				$430,100

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Administration and engineering, 10%			$43,000
Contingencies, 15%			64,500
Interest during construction, none			
TOTAL			$537,600
Annual Costs			
Interest, 3%			$16,100
Repayment, 0.887%			4,800
Replacement, 0.07%			400
Operation and maintenance			2,700
TOTAL			$24,000

ESTIMATED COST OF IRISH HILL PROJECT—Continued
Dry Creek-Clements Diversion

(Based on prices prevailing in April, 1953)

Elevation of crest of weir: 166 feet, U. S. G. S. datum
Height of weir above stream bed: 6 feet
Capacity of weir with 4.5-foot head: 42,000 second-feet
Capacity of diversion conduit: 85 second-feet

Length of conduit
Lined canal: 7.7 miles
Unlined canal: 4.5 miles
Goose Creek Siphon: 1,900 feet
Coyote Creek Siphon: 370 feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Diversion Works				
Dewatering and care of stream		lump sum	$10,000	
Stripping and excavation of cutoff	60,000 cu.yd.	$0.40	24,000	
Backfill of cutoff	54,000 cu.yd.	0.65	35,100	
Concrete				
Weir	7,860 cu.yd.	25.00	196,500	
Structural	30 cu.yd.	100.00	3,000	
Reinforcing steel	590,000 lb.	0.15	88,500	
Headgate		lump sum	1,000	
Sheet piling	12,500 sq.ft.	3.80	47,500	
Trash rack		lump sum	400	$406,000
Conduit				
Canal				
Excavation	18,700 cu.yd.	0.30	5,600	
Compaction	65,000 cu.yd.	0.50	32,500	
Trimming	90,500 sq.yd.	0.50	45,300	
Concrete lining	90,500 sq.yd.	3.50	316,800	
Goose Creek Siphon	1,900 lin.ft.	20.00	38,000	
Coyote Creek Siphon	370 lin.ft.	20.00	7,400	
Transitions	4 ea.	$250.00	1,000	
Road crossings	3 ea.	4,500	13,500	
Capital Costs—Continued				
Conduit—Continued				
Farm bridges	12 ea.	$3,000	$36,000	
Rights of way		lump sum	15,000	$511,100
Subtotal				$917,100
Administration and engineering, 10%				$91,700
Contingencies, 15%				137,800
Interest during construction, none				
TOTAL				$1,146,600
Annual Costs				
Interest, 3%				$34,400
Repayment, 0.887%				10,200
Replacement				600
Operation and maintenance				5,700
TOTAL				$50,900

ESTIMATED COST OF DELTA-STOCKTON DIVERSION PROJECT

(Based on prices prevailing in April, 1953)

Capacity of diversion and treatment works: 50 million gallons per day
Capacity of standby storage reservoir: 17 million gallons
Capacity of main conduit: 60 million gallons per day
Length of intake conduit: 20,200 feet
Length of main conduit: 15,000 feet
Main pipe lines to existing distribution system: 120,000 feet
Acreage served in city and environs: 20,800 acres

Item	Quantity	Unit price	Cost	
Capital Costs				
Diversion Works and Treatment Plant				
Diversion Pumping Plant				
Structural concrete	292 cu.yd.	$100.00	$29,200	
Reinforcing steel	38,000 lb.	0.15	5,700	
Excavation	200 cu.yd.	1.00	200	
Embankment	675 cu.yd.	0.50	300	
Access bridge		lump sum	7,500	
Concrete piling	2,775 lin.ft.	5.00	13,900	
Pumps and controls		lump sum	89,500	
Pipe (specials)		lump sum	20,000	
Check valves, 24" diameter	5 ea.	500.00	2,500	
Gate valves, 24" diameter	5 ea.	520.00	2,600	
Trash rack		lump sum	6,400	$177,800
Intake Conduit				
Mortar-lined steel pipe, 54" diameter	20,000 lin.ft.	32.00	646,400	
Concrete	1,478 cu.yd.	35.00	51,700	
Reinforcing steel	73,600 lb.	0.15	11,000	
Ring girders	153,000 lb.	0.60	91,800	
Wood piling	44,900 lin.ft.	4.50	202,100	
Painting	294,000 sq.ft.	0.20	59,000	
Road crossings	2 ea.	5,800	11,600	
Siphon		lump sum	95,700	1,169,300
Treatment Plant				
Plant		lump sum	5,500,000	
Fill (additional)	193,000 cu.yd.	0.30	57,900	5,557,900
High-lift Pumping Plant				
Structural concrete	625 cu.yd.	100.00	62,500	
Reinforcing steel	81,200 lb.	0.15	12,200	
Roofing	4,115 sq.ft.	1.50	6,200	
Excavation	5,850 cu.yd.	0.60	3,500	
Concrete piling	2,100 lin.ft.	5.00	10,500	
Pumps and controls		lump sum	155,100	
Wash water and sump pumps		lump sum	15,800	
Valves		lump sum	9,400	
Pipe (specials)		lump sum	12,900	
Crane and support		lump sum	6,000	
Foundation dewatering		lump sum	6,000	300,100
Rights of way	33 ac.	500.00	16,500	16,500
Subtotal				$7,221,600
Administration and engineering, 10%				$722,200
Contingencies, 15%				1,083,200
Interest during construction				270,800
Total, diversion works and treatment plant				$9,297,800
Main Conduit and Pipe Lines				
Pipe				
Reinforced-concrete cylinder				
48" diameter	15,000 lin.ft.	38.50	577,500	
36" diameter	13,600 lin.ft.	25.85	351,600	
30" diameter	27,000 lin.ft.	21.05	568,400	
24" diameter	14,200 lin.ft.	16.85	239,300	
Welded steel, No.7 gage				
22" diameter	1,100 lin.ft.	14.00	15,400	
20" diameter	20,400 lin.ft.	12.80	162,800	

Item	Quantity	Unit price	Cost	
Capital Costs—Continued				
Main Conduit and Pipe Lines—Continued				
Welded steel				
16" diameter	11,200 lin.ft.	$10.25	$114,800	
14" diameter	17,800 lin.ft.	9.25	164,700	
12" diameter	12,800 lin.ft.	8.00	102,400	
10" diameter	17,100 lin.ft.	6.80	116,300	$2,413,200
Subtotal				$2,413,200
Administration and engineering, 10%				$241,000
Contingencies, 15%				362,000
Interest during construction				90,000
Total, main conduit and pipe lines				$3,106,200
Booster Pumping Plant				
120' head, 14 million gal. per day capacity		lump sum	30,000	$30,000
Subtotal				$30,000
Administration and engineering, 10%				
Contingencies, 15%				$3,000
Interest during construction, none				4,500
Total, booster pumping plant				$37,500
TOTAL				$12,441,500
Annual Costs				
Diversion Works and Treatment Plant				
Interest, 3%				$278,900
Repayment, 0.887%				82,500
Replacement, 1.2%				110,600
Administration				46,900
Electric energy				101,400
Purification				80,200
Total, diversion works and treatment plant				$700,500
Main Conduit and Pipe Lines				
Interest, 3%				$93,200
Repayment, 0.887%				27,600
Replacement, 1.0%				31,100
Operation and maintenance, 1.0%				31,100
Total, main conduit and pipe lines				$183,000
Booster Pumping Plant				
Interest, 3%				$1,100
Repayment, 0.887%				300
Replacement, 1.2%				500
Electric energy				7,800
Operation and maintenance				12,800
Total, booster pumping plant				$22,500
TOTAL				$906,000

ESTIMATED COST OF NEW HOGAN PROJECT
New Hogan Dam and Reservoir

(Based on prices prevailing in April, 1953)

Elevation of crest of dam: 730 feet, U. S. G. S. datum
Elevation of crest of spillway: 711 feet
Height of dam to spillway crest, above stream bed: 182 feet
Capacity of reservoir to crest of spillway: 315,000 acre-feet
Maximum flood control reservation: 125,000 acre-feet
Capacity of spillway with 4-foot freeboard: 80,000 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Dam				
Diversion and care of river		lump sum	$30,000	
Stripping and preparation of foundation	911,600 cu.yd.	$1.00	911,600	
Embankment				
Impervious	1,518,600 cu.yd.	0.60	911,200	
Pervious	2,287,000 cu.yd.	0.60	1,372,200	
Drilling grout holes	21,300 lin.ft.	4.00	85,200	
Pressure grouting	21,300 cu.ft.	4.00	85,200	
Riprap	1,000 cu.yd.	3.00	3,000	$3,398,400
Auxiliary Dams				
Stripping and preparation of foundation	273,600 cu.yd.	1.00	273,600	
Embankment				
Impervious	193,500 cu.yd.	0.60	116,100	
Pervious	272,700 cu.yd.	0.60	163,600	553,300
Spillway				
Excavation	600,000 cu.yd.	1.00	600,000	
Concrete	6,500 cu.yd.	35.00	227,500	
Reinforcing steel	350,000 lb.	0.15	52,500	880,000
Outlet Works				
Tunnel				
Portal excavation	350,200 cu.yd.	2.50	875,500	
16′ diameter	400 lin.ft.	550.00	220,000	
24.5′ diameter	300 lin.ft.	1,080	324,000	
Concrete				
Structural	660 cu.yd.	100.00	66,000	
Plug	1,100 cu.yd.	20.00	22,000	
Stilling basin	400 cu.yd.	35.00	14,000	
Valves				
Butterfly, 10′ diameter	2 ea.	110,000	220,000	
Capital Costs—Continued				
Outlet Works—Continued				
Valves—Continued				
Butterfly, 7′ diameter	1 ea.	$45,000	$45,000	
Howell-Bunger, 10′ diameter	2 ea.	63,000	126,000	
Howell-Bunger, 7′ diameter	1 ea.	36,000	36,000	
Steel pipe, 10′ and 7′ diameters	496,000 lb.	0.25	124,000	
Reinforcing steel	152,000 lb.	0.15	22,800	
Trash rack steel	70,000 lb.	0.25	17,500	$2,112,800
Reservoir				
Land and improvements		lump sum	$409,700	
Utilities		lump sum	44,000	
Clearing	1,600 ac.	50.00	80,000	533,700
Subtotal				$7,478,200
Administration and engineering, 10%				747,800
Contingencies, 15%				1,121,700
Interest during construction				420,600
TOTAL				$9,768,300
Annual Costs				
Interest, 3%				$297,300
Repayment, 0.887%				87,900
Replacement, 0.07%				6,900
Operation and maintenance				26,000
TOTAL				$418,100

ESTIMATED COST OF NEW HOGAN PROJECT—Continued
Bellota-Linden Diversion

(Based on prices prevailing in April, 1953)

Elevation of crest of weir: 102 feet
Elevation of canal bottom at headworks: 96 feet
Capacity of diversion conduit: 125 second-feet
Length of conduit: 4.92 miles

Item	Quantity	Unit price	Cost	
Capital Costs				
Diversion Works				
Excavation	900 cu.yd.	$2.00	$1,800	
Backfill	900 cu.yd.	2.50	2,300	
Concrete	22 cu.yd.	100.00	2,200	
Reinforcing steel	2,200 lb.	0.15	330	
Trash rack steel	1,750 lb.	0.25	400	
Slide gate, 42″ diameter	2 ea.	600.00	1,200	
Resurfacing road		lump sum	500	
Corrugated pipe, 42″ diameter	280 lin.ft.	8.79	2,500	$11,200
Conduit				
Excavation	101,600 cu.yd.	0.30	30,500	
Compacted fill	62,000 cu.yd.	0.50	31,000	
Road crossings	6 ea.	2,000	12,000	
Concrete drops	117 cu.yd.	100.00	11,700	
Reinforcing steel	12,000 lb.	0.15	1,800	
Rights of way		lump sum	150,000	237,000
Subtotal				$248,200
Capital Costs—Continued				
Administration and engineering, 10%				$24,800
Contingencies, 15%				37,200
Interest during construction, none				
TOTAL				$310,200
Annual Costs				
Interest, 3%				$9,300
Repayment, 0.887%				2,800
Replacement, 0.07%				200
Operation and maintenance, 1.0%				3,100
TOTAL				$15,400

ESTIMATED COST OF NEW HOGAN PROJECT—Continued

Bellota-Farmington Diversion

(Based on prices prevailing in April, 1953)

Elevation of crest of weir: 120 feet
Elevation of canal bottom at headworks: 114 feet
Length of diversion weir: 100 feet
Height of weir crest, above stream bed: 9 feet

Capacity of diversion conduit: 85 second-feet
Capacity of weir with 10-foot surcharge: 22,300 second-feet
Length of conduit: 12.7 miles

Item	Quantity	Unit price	Cost	
Capital Costs				
Diversion Works				
Excavation	1,000 cu.yd.	$2.00	$2,000	
Concrete				
Weir	1,880 cu.yd.	30.00	56,400	
Sand trap	500 cu.yd.	60.00	30,000	
Reinforcing steel	90,000 lb.	0.15	13,500	
Trash rack steel	2,400 lb.	0.25	600	
Slide gate, 5′ x 5′	2 ea.	1,200	2,400	
Sluice gate, 30″ x 30″	2 ea.	600.00	1,200	
Steel hand railing		lump sum	200	
Flashboards on existing dam		lump sum	500	$106,800
Conduit				
Excavation	89,100 cu.yd.	0.30	26,700	
Compacted fill	83,000 cu.yd.	0.50	41,500	
Timber bridges	5 ea.	6,500	32,500	
Rights of way		lump sum	21,500	122,200
Subtotal				$229,000

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Administration and engineering, 10%			$22,900
Contingencies, 15%			34,400
Interest during construction, none			
TOTAL			$286,300
Annual Costs			
Interest, 3%			$8,600
Repayment, 0.887%			2,500
Replacement, 0.07%			200
Operation and maintenance, 1.0%			2,900
TOTAL			$14,200

ESTIMATED COST OF DELTA-LITTLEJOHNS DIVERSION PROJECT

(Based on prices prevailing in April, 1953)

Pumping plant capacity: 275 second-feet
Gross seasonal diversion: 60,000 acre-feet

Maximum monthly demand: 13,200 acre-feet
Acreage served: 8,000 acres

Item	Quantity	Unit price	Cost	
Capital Costs				
Pumping Plant No. 1				
Pumps, motors, and electrical equipment		lump sum	$124,500	
Sumps, trash racks, structure, and pipe line		lump sum	36,500	
Gate structure		lump sum	32,900	$193,900
Pumping Plants Nos. 2, 3, 4, and 5				
Pumps, motors, and electrical equipment	4 ea.	$58,500	234,000	
Sumps, trash racks, gates, and structures	4 ea.	24,300	97,200	331,200
Pumping Plants Nos. 6, 7, 8, and 9				
Pumps, motors, and electrical equipment	4 ea.	58,500	234,000	
Sumps, trash racks, gates, and structures	4 ea.	33,100	132,400	366,400
Pumping Plant No. 10				
Pumps, motors, and electrical equipment		lump sum	88,400	
Sumps, valves, and structure		lump sum	24,300	112,700
Conveyance System				
Channel excavation	230,000 cu.yd.	0.40	92,000	
Dredging French Camp Slough	10,000 cu.yd.	0.50	5,000	
Auxiliary check structures	4 ea.	10,000	40,000	
Pipe line		lump sum	116,400	
Rights of way	10.8 ac.	500.00	5,400	258,800
Subtotal				$1,263,000

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Administration and engineering, 10%			$126,300
Contingencies, 15%			189,500
Interest during construction			23,700
TOTAL			$1,602,500
Annual Costs			
Pumping Plants			
Interest, 3%			$38,200
Repayment, 0.887%			11,300
Replacement, 1.20%			15,300
Insurance, 0.12%			1,500
Operation and maintenance			35,000
Electric energy			165,600
Total, pumping plants			$266,900
Conveyance System			
Interest, 3%			$9,900
Repayment, 0.887%			2,900
Replacement, 0.07%			200
Operation and maintenance			1,600
Total, conveyance system			$14,600
TOTAL			$281,500

ESTIMATED COST OF NEW MELONES PROJECT
New Melones Dam and Reservoir

(Based on prices prevailing in April, 1953)

Elevation of crest of dam: 962 feet, U. S. G. S. datum
Elevation of crest of spillway lip: 915 feet
Height of dam to crest of gates, above stream bed: 445 feet
Capacity of reservoir to crest of spillway: 1,100,000 acre-feet
Capacity of spillway with 2-foot freeboard: 172,000 second-feet
Capacity of flood control reservation, November 1st to April 1st: 500,000 acre-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Dam				
Diversion and care of stream		lump sum	$100,000	
Stripping and preparation of foundation	779,400 cu.yd.	$3.00	2,338,200	
Concrete				
Mass	1,556,700 cu.yd.	14.00	21,793,800	
Reinforced, parapet and training walls	5,100 cu.yd.	40.00	204,000	
Reinforcing steel	3,449,000 lb.	0.15	517,400	
Miscellaneous metal	1,150,000 lb.	0.25	287,500	
Bridge		lump sum	48,000	
Drilling grout holes	3,600 lin.ft.	4.00	14,400	
Pressure grouting	2,400 cu.ft.	4.00	9,600	$25,312,900
Outlet Works				
Steel conduit	675,000 lb.	0.25	133,500	
Radial gates and hoists, 45′ x 60′	3 ea.	187,000	561,000	
Broome Gate, 14′ x 22′		lump sum	102,000	
Broome gate hoist		lump sum	85,000	
Needle valves, 84″ diameter	2 ea.	124,500	249,000	
High-pressure slide gates, 6′ x 8′	6 ea.	96,000	576,000	
Trash racks		lump sum	70,000	1,776,500

Item	Quantity	Unit price	Cost	
Capital Costs—Continued				
Reservoir				
Land		lump sum	$1,928,000	
Public utilities		lump sum	929,300	
Clearing	4,910 ac.	$100.00	491,000	3,348,300
Subtotal				$30,434,700
Administration and engineering, 10%				$3,043,500
Contingencies, 15%				4,565,200
Interest during construction				1,141,300
TOTAL				$39,184,700
Annual Costs				
Interest, 3%				$1,175,600
Repayment, 0.887%				347,600
Replacement, 0.07%				27,400
Operation and maintenance				70,500
TOTAL				$1,621,100

ESTIMATED COST OF NEW MELONES PROJECT—Continued
New Melones Power Plant

(Based on prices prevailing in April, 1953)

Capacity of power plant: 65,000 kilowatts
Location: Approximately ½ mile downstream from dam
Maximum head: 460 feet
Length of tunnel: 1,250 feet
Length of penstock: 130 feet
Diameter of penstock: 12 feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Tunnel	150 lin.ft.	$824.00	$123,600	
Penstock	130 lin.ft.	392.00	51,000	
Recondition existing tunnel	1,250 lin.ft.	300.00	375,000	
Power plant, 65,000 kilowatts		lump sum	6,000,000	$6,549,600
Subtotal				$6,549,600
Administration and engineering, 10%				$655,000
Contingencies, 15%				982,400
Interest during construction				245,000
TOTAL				$8,432,000

Item	Quantity	Unit price	Cost
Annual Costs			
Interest, 3%			$253,000
Repayment, 0.887%			74,600
Replacement, 1.20%			101,100
Insurance, 0.12%			10,100
Operation and maintenance			200,000
TOTAL			$638,800

ESTIMATED COST OF NEW MELONES PROJECT—Continued
Stanislaus-San Joaquin Diversion

(Based on prices prevailing in April, 1953)

STANISLAUS RIVER TO LITTLEJOHNS CREEK

Elevation of invert of canal at point of diversion: 428.3 feet
Elevation of invert of tunnel inlet: 425 feet
Elevation of invert of tunnel outlet: 412 feet

Capacity: 1,250 second-feet
Length of conduit
Canal: 5,200 feet
Tunnel: 6,800 feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Outlet Works				
Trash racks	45,000 lb.	$0.35	$15,800	
Two 6′ x 6′ high-pressure slide gates	140,000 lb.	0.60	84,000	
Two 7′ dia. steel pipes	55,000 lb.	0.30	16,500	
Two 6′ dia. hollow jet valves	120,000 lb.	0.60	72,000	
Gate house and transition		lump sum	10,000	
Concrete pipe	650 ft.	lump sum	123,000	$321,300
Canal				
Canal excavation	138,400 cu.yd.	2.20	304,500	
Canal lining	17,930 sq.yd.	3.50	62,800	
Creek bed excavations	125,000 cu.yd.	1.75	218,800	586,100
Tunnel	6,800 lin.ft.	215.00	1,462,000	$1,462,000
Subtotal				$2,369,400

Item	Quantity	Unit price	Cost
Capital Costs—Continued			
Administration and engineering, 10%			$236,900
Contingencies, 15%			355,400
Interest during construction, 1.5%			44,400
TOTAL			$3,006,100
Annual Costs			
Interest, 3%			$90,200
Repayment, 0.887%			26,700
Replacement, 0.02%			600
Operation and maintenance			6,700
TOTAL			$124,200

ESTIMATED COST OF NEW MELONES PROJECT—Continued
Stanislaus-San Joaquin Diversion

(Based on prices prevailing in April, 1953)

LITTLEJOHNS CREEK TO MILTON

Elevation of invert of canal at point of diversion from Littlejohns Creek: 325.0 feet
Elevation of invert of canal at lower end of reach: 273.9 feet

Capacity of diversion conduit: 770 second-feet
Length of conduit
Lined canal: 25.4 miles
Flume: 1.36 miles

Item	Quantity	Unit price	Cost	
Capital Costs				
Diversion Dam		lump sum	$20,000	
Canal				
Excavation	1,057,800 cu.yd.	$0.30	317,300	
Embankment	556,700 cu.yd.	0.35	194,800	
Concrete lining	630,300 sq.yd.	2.75	1,733,300	
Right of way	357 ac.	100.00	35,700	
Bridges		lump sum	133,800	$2,414,900
Flume		lump sum	700,500	700,500
Subtotal				$3,135,400
Administration and engineering, 10%				$313,500
Contingencies, 15%				470,300
Interest during construction, 1.5%				58,800
TOTAL				$3,978,000

Item	Quantity	Unit price	Cost
Annual Costs			
Interest, 3%			$119,300
Repayment, 0.887%			35,300
Replacement, 0.02%			800
Operation and maintenance, 0.5%			19,900
TOTAL			$175,300

ESTIMATED COST OF NEW MELONES PROJECT—Continued
Stanislaus-San Joaquin Diversion

(Based on prices prevailing in April, 1953)

MILTON TO CALAVERAS RIVER
Elevation of invert of canal at upper end of reach: 273.9 feet
Elevation of invert of canal at lower end of reach: 234.7 feet
Capacity: 420 second-feet

Length of conduit
Lined canal: 20.9 miles
Flume: 1.7 miles

Item	Quantity	Unit price	Cost		Item	Quantity	Unit price	Cost
Capital Costs					**Annual Costs**			
Canal					Interest, 3%			$81,800
Excavation	562,900 cu.yd.	$0.30	$168,900		Repayment, 0.887%			24,200
Embankment	299,700 cu.yd.	0.35	104,900		Replacement, 0.02%			500
Lining	425,500 sq.yd.	2.75	1,170,100		Operation and maintenance, 0.5%			13,600
Right of way	246 ac.	100.00	24,600		TOTAL			$120,100
Bridges		lump sum	99,200					
Flume		lump sum	582,500	$582,500				
Subtotal				$2,150,200				
Administration and engineering, 10%				$215,000				
Contingencies, 15%				322,500				
Interest during construction, 1.5%				40,300				
TOTAL				$2,728,000				

ESTIMATED COSTS OF NEW MELONES PROJECT—Continued
Stanislaus-San Joaquin Diversion

(Based on prices prevailing in April, 1953)

CALAVERAS RIVER TO BEAR CREEK
Elevation of invert of Calaveras River siphon inlet: 234.7 feet
Elevation of invert of Calaveras River siphon outlet: 212.0 feet
Elevation of invert of canal at Bear Creek terminal: 190.3 feet
Capacity: 210 second-feet

Length of conduit
Canal: 11.8 miles
Siphon: 1.8 miles
Flume: 0.7 mile

Item	Quantity	Unit price	Cost		Item	Quantity	Unit price	Cost
Capital Costs					**Annual Costs**			
Canal					Interest, 3%			$47,800
Excavation	175,400 cu.yd.	$0.30	$52,600		Repayment, 0.887%			14,100
Embankment	108,000 cu.yd.	0.35	37,800		Replacement, 0.02%			300
Concrete lining	186,300 cu.yd.	2.75	512,300		Operation and maintenance, 0.5%			8,000
Right of way	112 ac.	100.00	11,200		TOTAL			$70,200
Bridges		lump sum	45,600	$659,500				
Flume		lump sum	159,200	159,200				
Siphon								
Steel pipe, 6-foot dia.	1,744,000 lb.	0.25	436,000	436,000				
Subtotal				$1,254,700				
Administration and engineering, 10%				$125,500				
Contingencies, 15%				188,200				
Interest during construction, 1.5%				23,500				
TOTAL				$1,591,900				

ESTIMATED COSTS OF NEW MELONES PROJECT—Continued
Stanislaus-San Joaquin Diversion

(Based on prices prevailing in April, 1953)

BEAR CREEK TO MOKELUMNE RIVER
Elevation of invert of canal at upper end of reach: 120 feet
Elevation of invert of canal at lower end of reach: 75 feet
Capacity: 105 second-feet

Length of conduit
Lined canal: 1.7 miles
Pipe: 0.15 mile
Flume: 0.15 mile

Item	Quantity	Unit price	Cost	
Capital Costs				
Diversion Dam		lump sum	$5,000	$5,000
Canal				
Excavation	10,820 cu.yd.	$0.30	3,200	
Embankment	9,240 cu.yd.	0.35	3,200	
Concrete lining	19,550 sq.yd.	2.75	53,800	
Right of way	10 ac.	500.00	5,000	
Bridges		lump sum	3,200	68,400
Flume		lump sum	19,200	19,200
Pipe line				
5″ dia. steel pipe	70,400 lb.	0.30	21,100	
Jacking pipe	150 lin.ft.	50.00	7,500	
54″ hollow jet valve	30,000 lb.	0.60	18,000	46,600
Subtotal				$139,200
Administration and engineering, 10%				13,900
Contingencies, 15%				20,900
Interest during construction, 1.5%				2,600
TOTAL				$176,600

Item	Quantity	Unit price	Cost
Annual Costs			
Interest, 3%			$5,300
Repayment, 0.887%			1,600
Replacement, 0.02%			
Operation and maintenance, 0.5%			900
TOTAL			$7 800

ESTIMATED COSTS OF NEW MELONES PROJECT—Continued
Flood Road-Stockton Diversion

(Based on prices prevailing in April, 1953)

Elevation of crest of dam: 248 feet, U. S. G. S. datum
Elevation of crest of spillway lip: 240 feet
Height of dam to crest of spillway, above stream bed: 35 feet
Capacity of reservoir to crest of spillway: 5,500 acre-feet
Capacity of spillway with 4-foot freeboard: 400 second-feet

Item	Quantity	Unit price	Cost	
Capital Costs				
Dam and Reservoir				
Stripping	34,000 cu.yd.	$0.40	$13,600	
Embankment				
Impervious	63,700 cu.yd.	0.40	25,500	
Pervious	59,300 cu.yd.	0.75	44,500	
Outlet Works		lump sum	4,000	
Spillway				
Excavation	550 cu.yd.	0.65	400	
Reinforcing steel	38,000 lb.	0.12	4,600	
Concrete	510 cu.yd.	40.00	20,400	
Lands	300 ac.	120.00	36,000	
Subtotal				$149,000
Administration and engineering, 10%				14,900
Contingencies, 15%				22,400
Interest				2,800
TOTAL				$189,100
Treatment Works				
Filtration plant		lump sum	1,257,500	
Storage tank		lump sum	765,000	
Chemical building		lump sum	43,000	
Subtotal				$2,065,500
Administration and engineering, 10%				$206,600
Contingencies, 15%				309,800
Interest				38,700
TOTAL				$2,620,600
Conveyance System				
Pipe				
48-inch dia. welded steel	6.06 mi.	$130,000	$788,000	
60-inch dia. welded steel	17.61 mi.	190,000	3,346,000	
Subtotal				$4,134,000
Administration and engineering, 10%				$413,400
Contingencies, 15%				620,100
Interest				77,500
TOTAL				$5,245,000
Distribution System				
Pipe				
36-inch dia. R.C. cylinder	13,600 lin.ft.	25.85	351,600	
30-inch dia. R.C. cylinder	27,000 lin.ft.	21.05	568,400	
24-inch dia. R.C. cylinder	14,200 lin.ft.	16.85	239,300	
22-inch dia. steel cylinder	1,100 lin.ft.	14.00	15,400	
20-inch dia. steel clyinder	20,400 lin.ft.	12.80	162,800	
16-inch dia. steel cylinder	11,200 lin.ft.	10.25	114,800	
14-inch dia. steel cylinder	17,800 lin.ft.	9.25	164,700	
Capital Costs—Continued				
Distribution System—Continued				
Pipe—Continued				
12-inch dia. steel cylinder	12,800 lin.ft.	$8.00	$102,400	
10-inch dia. steel cylinder	17,100 lin.ft.	6.80	116,300	$1,835,700
Booster pumping plant, 120-foot head, 14 million gallons per day capacity		lump sum	30,000	30,000
Subtotal				$1,865,700
Administration and engineering				$186,600
Contingencies				279,800
Interest				70,000
TOTAL				$2,402,100
GRAND TOTAL				$10,456,800
Annual Costs				
Dam and Reservoir				
Interest, 3%				$5,700
Repayment, 0.887%				1,700
Replacement, 0.02%				
Operation and maintenance				600
Subtotal				$8,000
Treatment Works				
Interest, 3%				$78,700
Repayment, 0.887%				23,100
Replacement, 1.2%				31,500
Operation and maintenance				60,000
Subtotal				$193,300
Conveyance System				
Interest, 3%				$157,400
Repayment, 0.887%				46,500
Replacement, 0.02%				1,000
Operation and maintenance, 0.5%				26,200
Subtotal				$231,100
Distribution System				
Interest, 3%				$72,100
Repayment, 0.887%				21,300
Replacement, 0.02%				500
Operation and maintenance, 0.5%				12,000
Electrical energy				7,800
Subtotal				$113,700
TOTAL				$546,100

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